MERRIMACK RIVER BASIN

SALEM, NEW HAMPSHIRE

WHEELER DAM
ARLINGTON MILL RESERVOIR
NH 00028

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1978

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14. ABSTRACT
Wheeler Dam is located in the town of Salem, New Hampshire on the Spicket River, a tributary of the Merrimack River. It impounds Arlington Mill Reservoir. It is a concrete gravity dam with earth abutments constructed in 1920. Overall length is 730 feet and maximum height is 54 feet. The Spicket River flows from the dam through the eastern portion of Salem and thence through Methuen and Lawrence, Mass, where it joins the Merrimack. The dam is in significant-to-high hazard class, due to its height and position upstream from populated areas. Design and construction records are sufficient to get a general picture, but lack detail.

Wheeler Dam is assessed to be in poor condition due primarily to unusual and severe concrete surface spalling, aggravated in places by erosion. Other problems include one active seepage through an earth embankment, inoperative condition of two of the three discharge gates, and advanced vandalism damage to gate house.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:
NEDED

SEP 28 1978

Honorable Meldrim Thomson, Jr.
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Thomson:

I am forwarding to you a copy of the Wheeler Dam Arlington Mill Reservoir Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Spicket River Corp., 550 Broadway, Lawrence, Massachusetts 01841.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam Wheeler Dam, Arlington Mill Reservoir

State Located New Hampshire

County Located Rockingham

City or Town Salem

Stream Spicket River

Date of Inspection 6/7/78 and 6/28/78

Brief Assessment

Wheeler Dam is located in the Town of Salem, New Hampshire on the Spicket River, a tributary of the Merrimack River. It impounds Arlington Mill Reservior. It is a concrete gravity dam with earth abutments constructed in 1920. Overall length is 730 feet and maximum height is 54 feet. The Spicket River flows from the dam through the eastern portion of Salem and thence through Methuen and Lawrence, Mass. where it joins the Merrimack. The dam is in the significant-to-high hazard class, due to its height and position upstream from populated areas. Design and construction records are sufficient to get a general picture, but lack detail.

Wheeler Dam is assessed to be in poor condition due primarily to unusual and severe concrete surface spalling, aggravated in places by erosion. Other problems include one active seepage through an earth embankment, inoperative condition of two of the three discharge gates, and advanced vandalism damage to the gate house.

The spillway capacity of the dam is computed to be about 12,600 cubic feet per second (c.f.s.). The selected test flood (equal to the probable maximum flood) has a peak inflow into the reservoir of about 22,000 cfs and a peak outflow at the dam of about 20,000 cfs. This peak outflow would overtop the earth embankments by about one foot. It is not known whether the structure could withstand this degree of overtopping, though it does show that the dam is not highly inadequate from a hydraulic standpoint.

It is urgently recommended that the owner retain a competent engineer specializing in concrete problems to fully investigate the cause or causes of the concrete spalling and to propose a remedy within six months to one year. Furthermore, it is recommended that the owner promptly carry out such remedy. Other problems require retaining professional advice and taking actions on matters of a more routine, but important nature.

WHITMAN & HOWARD, INC.

T. T. Chiang

T.T. Chiang, PhD., P.E.

THE STATE OF NEW HAMPSHIRE
TSUNG-TING
CHIANG
No. 3049
REGISTERED
PROFESSIONAL ENGINEER

John L. Scott

John L. Scott, P.E.

THE STATE OF NEW HAMPSHIRE
JOHN
L.
SCOTT
No. 3884
REGISTERED
PROFESSIONAL ENGINEER

This Phase I Inspection Report on Wheeler Dam, Arlington Mill Reservoir has been reviewed by the undersigned Review Board members. In our opinion the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Charles G. Tiersch

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

Fred J. Ravens Jr.

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

Saul Cooper

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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SALEM, NEW HAMPSHIRE

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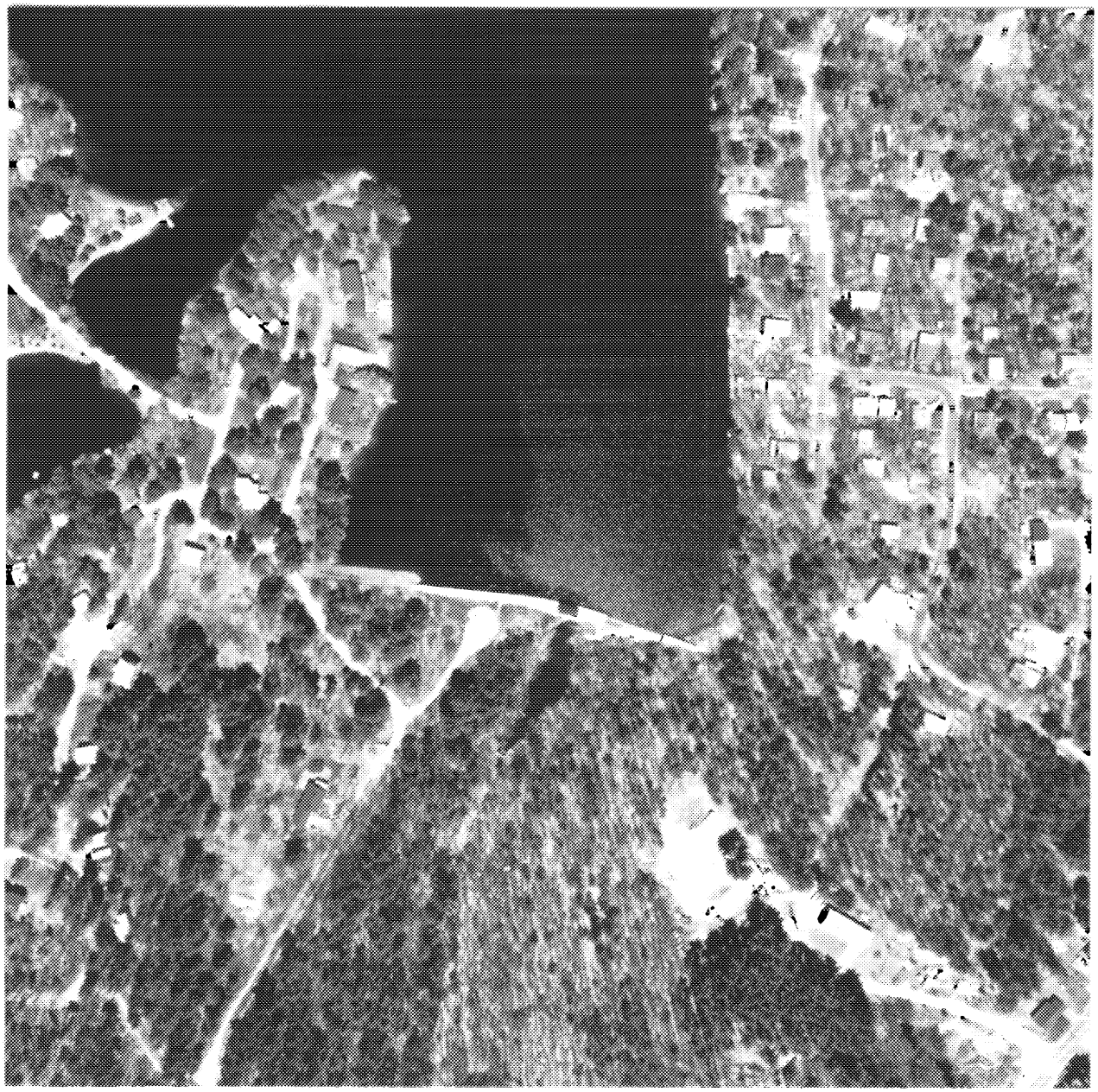
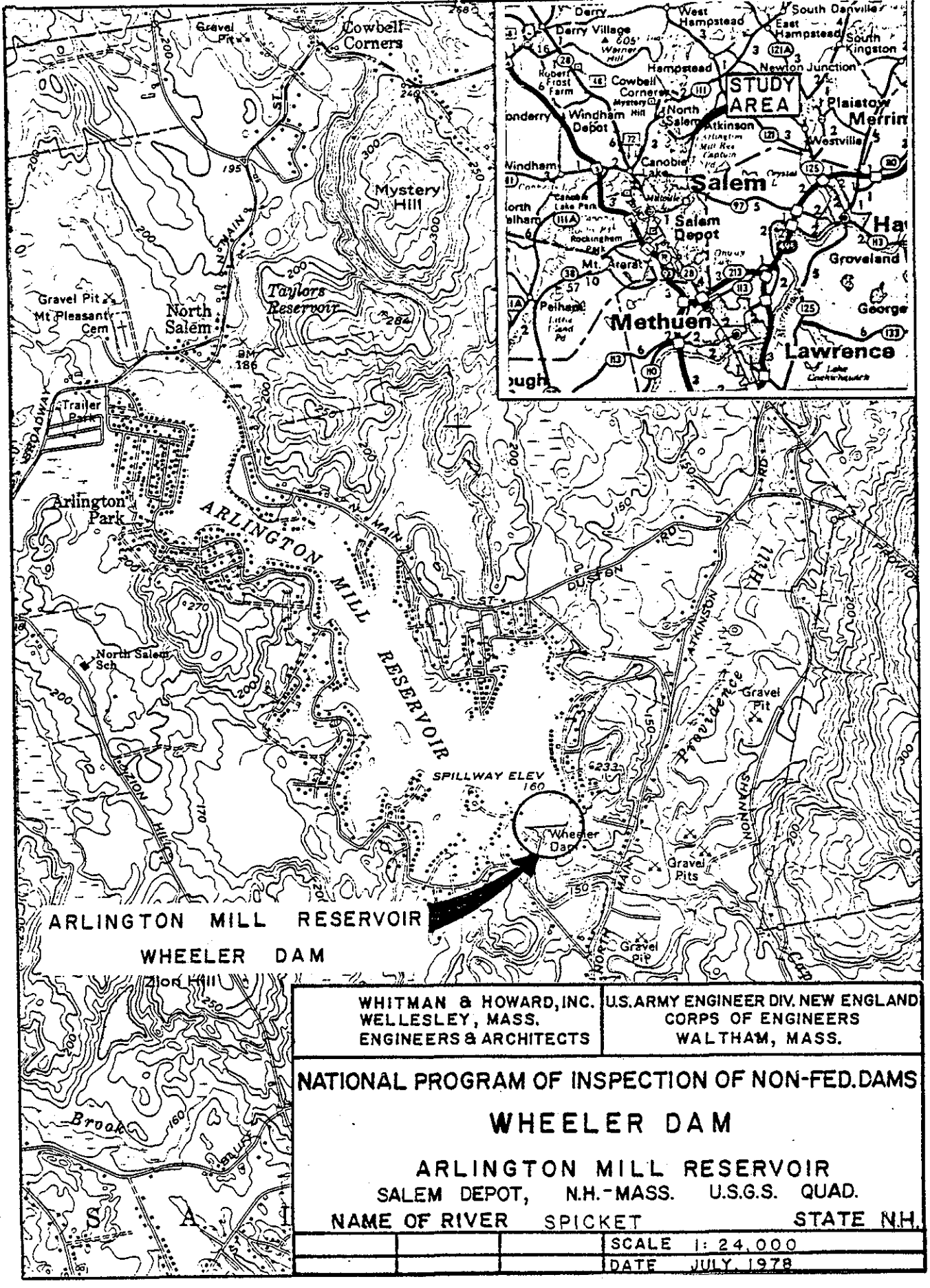


WHEELER DAM

ARLINGTON MILL RESERVOIR

Salem, N.H.

Approx. Scale 1" = 280'



WHITMAN & HOWARD, INC. WELLESLEY, MASS. ENGINEERS & ARCHITECTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

WHEELER DAM

ARLINGTON MILL RESERVOIR

SALEM DEPOT, N.H.-MASS. U.S.G.S. QUAD.

NAME OF RIVER SPICKET STATE N.H.

SCALE 1: 24,000

DATE JULY, 1978

PHASE I INSPECTION REPORT

WHEELER DAM ARLINGTON MILL RESERVOIR

NH 00028

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Whitman & Howard, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to Whitman & Howard, Inc. under a letter of May 1, 1978 from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0313 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location - Wheeler Dam is located in the Town of Salem, N.H. on the Spicket River, a tributary of the Merrimack River. It impounds the Arlington Mill Reservoir. The dam appears on the USGS quadrangle "Salem Depot, NH-Mass".

b. Description of Dam and Appurtenances - Wheeler Dam is a concrete gravity dam with earth abutments, built upon ledge. The concrete portion is approximately 500 feet long with a maximum structure height of 54 feet. A 100 foot long spillway was built integrally with the main dam, with a crest elevation of 160 feet msl and a gross freeboard of 8 feet to the top of the dam. A 2 foot flash board system is employed. Discharge is controlled from a gate house atop the dam with manual controls for three 48" steel conduits at different elevations. These are two submerged intake portals which bring water from different depths. The total drainage area at the dam is 23.5 sq. mi., of which 17.1 sq. mi. is controlled thru the Big Island Pond Dam.

c. Size Classification - The height of the dam and volume of impounded water place Wheeler Dam in the "Intermediate" size class.

d. Hazard Classification - Wheeler Dam is in the significant-to-high hazard class, due to its height and position upstream from populated areas. The Spicket River flows from the dam through the eastern part of the Town of Salem, past several residential developments, and thence through urban portions of Methuen and Lawrence, Mass. The height and volume of a flood wave generated by failure of the dam would be sufficient to cause significant loss of life and property. The flat and swampy nature of the terrain would cause a fairly rapid dissipation of the flood wave, but not before considerable damage was done.

e. Ownership - The dam is owned by the Spicket River Corp., a wholly-owned subsidiary of Greater Lawrence Industrial Associates, 550

Broadway, Lawrence, Mass. The dam has always been in the possession of the owners of the former Arlington Mill complex in Lawrence.

f. Operator - Harlan Low, c/o 550 Broadway, Lawrence, Mass. 617/686-3846.

g. Purpose of Dam - The dam was constructed to store water and regulate flow for industrial use. It is the largest of a series of dams and impoundments constructed or acquired by these mills to avoid dry weather shut-downs. No natural lake existed prior to the construction of Wheeler Dam, the Arlington Mill Reservoir being a totally artificial impoundment.

h. Design and Construction History - Wheeler Dam was designed by H.K. Barrows, a prominent Boston civil engineer. Construction was begun in Oct. 1921 and was completed in Dec. 1922. Two dikes, the East Dike and the West Dike, were constructed in conjunction with Wheeler Dam and are covered in separate reports.

The lake shore of Arlington Mill Reservoir is almost fully developed with vacation cottages and year-round homes, making general recreation an important secondary purpose. There has been controversy about lake levels and dam operation, especially in dry years, although the dam owners appear to have firm legal rights to the water.

i. Normal Operating Procedures - Spring runoff is stored for steady release in summer months. The water is used for industrial cooling. In dry years, the pond is drawn down considerably.

1.3 Pertinent Data

a Drainage Areas

23.5 sq. mi., of which 17.1 sq. mi. are controlled at Big Island Pond Dam upstream. The basin is intermediate between flat and rolling terrain.

b. Discharge at Damsite

Maximum known flood at damsite Unknown

Warm water outlet at pool elevation N/A

Discharge conduit capacity:*

1300 cfs @ elev. 160
1450 cfs @ elev. 166

*Assumes all 3 pipes open

Gated spillway capacity at pool elevation N/A - ungated

Gated spillway capacity at maximum pool elevation N/A - ungated

Ungated spillway capacity at maximum pool elevation 6300 cfs

Total spillway capacity at maximum pool elevation 7750 cfs

c. Elevation (ft. above MSL)

(1) Top Dam - 168.1 (top of concrete); 169 (top of earth embankments)

(2) Maximum pool-design surcharge - 166. (Flashboards reportedly designed to fail between elev. 164 & 166).

(3) Full flood control pool - N/A

(4) Recreation pool - 160. (Top of flash-boards 162.1

(5) Spillway crest - Permanent crest 160. Flashboards 2.1' height.

(6) Upstream portal invert diversion tunnel - 131 (lower) 148 (upper)

Downstream portal invert diversion tunnel - 131, 126, & 121 (3 conduits)

(7) Streambed at centerline of dam - Approximately 120

(8) Maximum tailwater - Unknown

d. Reservoir

(1) Length of maximum pool - Approx. 11,000' at elev. 168

(2) Length of recreation pool - 9,600' at elev. 160

(3) Length of flood control pool - N/A

e. Storage (acre-feet)

(1) Recreation Pool - 3,360 (@ elev. 160)

(2) Flood control pool - N/A

(3) Design Surcharge - 5,060 (@ elev. 166)

(4) Top of Dam - 5,680 (@ elev. 168)

f. Reservoir Surface (acres)

(1) Top Dam - Est. 320 acres

(2) Maximum pool - Est. 300 acres

(3) Flood-control pool - N/A

(4) Recreation pool - 266 acres @ elev. 160

(5) Spillway crest - 266 acres @ elev. 160 (12 acres at elev. 132)

g. Dam

(1) Type - Concrete gravity dam with earth abutments

(2) Length - Concrete section 500', including 100' spillway

(3) Height - Top of concrete to ledge at max. ht. = 54'

(4) Top Width - 8'

(5) Side Slopes - Upstream face vertical; downstream batter 5-3/4:12.

(6) Zoning - N/A

(7) Impervious Core - Earth abutments have concrete core wall to ledge.

(8) Cutoff - Concrete core wall

(9) Grout curtain - N/A

h. Diversion and Regulating Tunnel

(1) Type - Three 48" steel conduits

(2) Length - From gate well through base of dam - approx. 12 ft

(3) Closure - Circular sluice gate on each conduit

(4) Access - Manual operation from gate house atop dam

(5) Regulating Facilities - Manual operation (hand crank operators)

i. Spillway

(1) Type - Concrete ogee, integral with dam

(2) Length of weir - 100 ft

(3) Crest elevation - 160 m.s.l.

(4) Gates - No gates - Wood Flashboards 2.1' height

(5) U/S Channel - None as such

(6) D/S Channel - Base of spillway built on ledge. Water flows over ledge to natural river channel at base of dam.

j. Regulating Outlets

Weir structure 500' downstream for measuring discharge (cannot be used for regulating flow). Structure not presently used.

SECTION 2: ENGINEERING DATA

2.1 Design

Wheeler Dam is designed as a concrete gravity dam with earth abutments having a concrete core wall. The entire dam is on ledge. See the plate and designer's report in Appendix B and the general description in 1.2.

2.2 Construction

Many photos and inspection reports combine to form a fairly good record of construction. However, details on soils and geology are lacking.

2.3 Operation

Lake level reports exist for many years, but data are not continuous. (Operation is fairly simple and unsophisticated.)

2.4 Evaluation

a. Availability - Construction plans (fairly detailed), designer's report, many construction photos and inspector's reports are on file with the N.H. Water Resources Board and some plans and records are with the owner.

b. Adequacy - Good. Few unknowns, except for details of soils and geology.

c. Validity - Good. Plans appear to match as-built conditions for the important features. Operation records are plausible.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The first-time visitor is immediately struck with the poor appearance of the concrete surfaces. This condition has led to frequent inquiries regarding the safety of the dam.

b. Dam

All concrete surface show spalling, varying from moderate to severe, aggravated in places by erosion. See Section 6, Structural Stability, for further discussion on this condition.

Many of the handrail posts have rotted at the base, rendering the handrail unreliable. The steps have spalled badly enough to cause a falling hazard. Some sections of the downstream face show signs of an unsuccessful gunite application, as large lenses of loose concrete lie at the base.

The gate house is suffering from the effects of vandalism. The door and windows are missing, and some of the gatewell floor covers have been removed, leaving a dangerous condition. The gate to the upper outlet pipe, which is normally used to regulate flow, was operated successfully except for a small amount of leakage when shut. The custodian declined to operate the other two gates, as they are not regularly used. The outlet pipes are somewhat rusty, and the lowest outlet pipe is half buried in bottom sediment.

The flashboards seem in good condition, and visual observation of the pin arrangement supports the owners contention that they would bend over and release before overtopping, as they should. The spillway surface exhibits a normal amount of erosion, except for the ends of the wingwalls which has substantially eroded away.

c. Appurtenent Structures

A concrete sharp crested weir structure is situated approximately 500 feet downstream, which at one time was used to record flow. There is a small enclosure to one side suitable to house recording equipment. The structure is in moderate disrepair, although restorable. It has been neglected for many years.

Two remote dikes, the East Dike and the West Dike, were built along with Wheeler Dam, and are covered in separate inspection reports as part of the National Dam Safety Program.

d. Reservoir Area

Arlington Mill Reservoir is extensively developed with summer cottages.

e. Downstream Channel

The downstream channel has many overhanging trees and vegetation, though this condition is not severe.

3.2 Evaluation

The spalling of the concrete is considerably worse than what would normally be expected from a concrete structure of this age. Possible causes include improper placement, lack of air entrainment, or mineral attack of the cement. It should be a high priority to determine the actual cause or causes and to seek and accomplish a remedy.

The other problems, such as the inoperable gates, embankment seep, and vandalism damage, though extensive, can be routinely addressed.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Flashboards are kept on year round. The upper outlet conduit is opened when water level is below the top of flashboards. Gate opening is adjusted according to the quantity of stream flow needed by the owner.

4.2 Maintenance of Dam

Occasional observation visits - very little real maintenance on dam.

4.3 Maintenance of Operating Facilities

The one gate which is still used is greased occasionally and is in good working condition. The other two gates are unused. Structure of the gate house has been vandalized and left unrepaired.

4.4 Description of any Warning System in Effect

None.

4.5 Evaluation

Operation procedure is simple and unsophisticated, but suitable. Maintenance has been somewhat neglected. Much repair and clean-up work is needed.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

Hydraulic/hydrologic data from the time of the dam design are not available. The criteria for the choice of the spillway length and freeboard height are unknown.

b. Experience Data

No records have been kept of the dam's performance in flood situations.

c. Visual Observation

As can be seen in the dam profile (see Appendix B), the earth embankments are one foot higher than the main concrete section. From visual inspection, the dam appear capable of withstanding an overtopping of 1' above the top of the concrete without washing out. Theoretical spillway capacity could include this extra margin.

The wing walls on each side of the spillway do not appear high enough to contain high flows. This could cause unnecessary erosion to the toe of the left embankment, weakening its resistance to overtopping.

d. Overtopping Potential

Reference is made to Appendix D for the hydrologic computations performed as a part of this report.

The peak inflow into Arlington Mill Reservoir of the Probable Maximum Flood (PMF) is computed to be about 22,300 cfs. The PMF is defined as the largest flood that can reasonably

be expected to occur on a given stream at a selected point, or the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

For structures of the size and hazard classification of Wheeler Dam, the "test flood" is generally selected as the full PMF. The test flood is that flood used to evaluate the hydraulic adequacy of a project. The test flood for Wheeler Dam is chosen as the full PMF.

If the upstream Big Island Pond Dam were to remain intact during the test flood condition, the peak inflow into Arlington Mill Reservoir would be reduced from 22,300 cfs to about 17,000 cfs, due to the surcharge storage effect in Big Island Pond. However, it has been determined that Big Island Pond Dam will likely fail under flows well below this test flood. (See Phase I report for Big Island Pond Dam, NH 00470.) Therefore, the evaluation of the hydraulic adequacy of Wheeler Dam should not rely upon the surcharge effect of Big Island Pond.

Assuming Wheeler Dam remains intact, the peak outflow during the test flood would be about 19,800 cfs, the reduction from the inflow of 22,300 cfs being accounted for by the surcharge storage effect of Arlington Mill Reservoir. At the moment of this peak outflow, the water surface would be about 170.3 ft. msl or 1.3 ft above the top of the earth embankments of Wheeler Dam and also those of the East Dike and West Dike.

The spillway capacity of Wheeler Dam, including the capacity of the three discharge conduits and also the extra capacity of one foot of flow over the main concrete portion, is computed to be about 12,600 cfs, or 64% of the peak outflow during the test flood. Overtopping potential is judged as moderate.

It must be mentioned that should Big Island Pond Dam fail suddenly in the later stages of a severe flood (after building up a large hydraulic head) the impact of the resulting flood wave could wipe out Wheeler Dam and the two dikes.

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There is one serious structural problem with a direct bearing on structural stability. The exposed concrete surfaces are in a fairly advanced state of spalling, particularly at construction joints and non-vertical surfaces. This problem is one of long term deterioration and is evident even in the earliest inspection photos and reports. The spalling is aggravated at points of erosion such as the edges and ends of the spillway wing walls. The general problem was addressed in an engineering report prepared for the owners in 1963. The report concluded that the deterioration at that time had not yet effected structural stability, but that the process would continue and "corrective measures" would have to be taken when the maximum depth of spalling at any one point reached 18" at some undetermined future time. The report recommended a detailed monitoring program, which was not apparently carried out.

In September, 1973, staff engineers from the New England Division, U.S. Army Corps of Engineers, inspected Wheeler Dam in response to requests from officials of Salem, N.H., and Methuen, Mass. Noting the concrete problems, their subsequent report stated that "it would be prudent to make a more detailed survey of the dam including core samples taken at selected locations to determine the quality of the concrete in the interior of the structure".

Other problems worthy of note are: (1) a small but active seep at the toe of the right abutment near its juncture with the concrete portion and (2) damp construction joints at several locations. According to recent

reports, these sometimes develop running leaks. This condition is no doubt related to the overall spalling problem.

b. Design and Construction Data

From the available construction plans, designer's report, and construction photos, plus the reputation of chief engineer, it is fairly obvious that the design and construction of Wheeler Dam was a professional effort. The site was well chosen with a solid ledge foundation. The slight curvature of the highest portion is a good feature, adding strength and overturning resistence where it is most needed.

c. Operating Records

There is no reported history of settlement, cracks or structural distress during flooding and no visual evidence of this type.

d. Post-Construction Changes

There have been no significant post-construction changes to the dam structure.

e. Seismic Stability

The dam is located in a Seismic Zone 2, and hence does not have to be evaluated for seismic stability according to the OCE Recommended Guidelines.

SECTION 7: ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition

Wheeler Dam is assessed to be in poor condition, primarily due to the concrete problem.

b. Adequacy of Information

Regarding the concrete problem, there is a substantial body of reports, letters, photographs and other information pointing to a long-term, steadily deterioriting condition. The information is adequate to strongly support the judgment that the problem be fully addressed within six months to one year.

Regarding the maintenance problems, the visual observations are adequate to make recommendations.

Regarding soils and geology, the absence of data in this area at the time of construction means that the assessment must be made on the basis of visual inspection.

c. Urgency

The recommendations and remedial measures below should be implemented in the following time frames:

Feature	Time Frame for Modifications
Concrete	6 Months - 1 Year
Maintenance	1-2 years
Embankments	2-4 years

d. Need for Additional Investigation

Due to the condition of the concrete and the visible areas, there is a need to inspect the surface of the upstream face and to take concrete cores to determine the condition of the concrete in the interior of the dam.

Other problems will also require engineering input, analyses, and design.

7.2 Recommendations

The owner should:

(1) Retain a competent engineer with special experience in concrete problems, to investigate and determine the cause or causes of the concrete spalling and to recommend a remedy.

(2) Carry out whatever remedy results from (1) above.

(3) Hire a competent mechanic to render all three discharge conduits in good operating condition.

(4) Remove the sediment blocking the bottom gate.

(5) Cut the brush and trees on the embankment.

(6) Repair the gate house vandalism damage.

(7) Obtain professional advice to establish a logical warning system for downstream areas in case of dam failure.

(8) Provide erosion protection (e.g., riprap) on the portion of the downstream face of the left embankment susceptible to flow spilling over the top of the left spillway wing wall.

7.3 Remedial Measures

a. Alternatives

The only alternative to the recommended actions, short of permanently draining the reservoir and breaching the dam, would be to sell or turn over the dam and water rights to a private or public entity willing to undertake the necessary work.

b. Operation and Maintenance

(1) The gates on all three conduits should be exercised regularly.

(2) The flashboards and pins should be inspected regularly to assure proper release capability is maintained.

(3) The embankments should henceforth be kept clear of all trees and shrubs. A dense growth of grass should be maintained.

(4) A more conscientous method of preventing trespass should be adopted.

(5) A program of regular observation visits by a responsible individual should be adopted. Visits should be at least twice a week and a permanent log kept.

WHEELER DAM

APPENDICES

Appendix	Description
A	Visual Inspection Checklist - 11 pp.
B	Engineering Data with Index
C	Inspection Photographs with Index - 12 Photos
D	Hydrologic Computations
E	Information as Contained in the National Inventory of Dams

APPENDIX A

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Wheeler Dam
Arlington Mill Reservoir

DATE June 6, 1978*

TIME 9:00 AM start

WEATHER sunny - warm

W.S. ELEV. 162.2 U.S. 123 DN.S.
(approx. 1" above flashboards)

PARTY: *

1. E. Chiang, Whitman & Howard
2. J. Scott, Whitman & Howard
3. Harlan Low, custodian for owner
4.
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	All Features	Chiang & Scott	
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

*Additional visit - see next page.

Checklist combines notes of both visits.

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Wheeler Dam, Arlington Mill Reservoir

DATE June 28, 1978

TIME 1:00 PM start

WEATHER sunny - hot

W.S. ELEV. 162.0 U.S. 122 DN.S.
(approx. 1" below flashboards - small flow on spillway due to wave action)

PARTY: *

1. J. Scott, Whitman & Howard
2. R. Hirschfeld, Geotechnical Engineers, Inc.
3.
4.
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	All Features	Scott & Hirschfeld	
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

*Second visit - see previous page for first visit.

Check List combines notes of both visits.

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE Main Concrete Section NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	Moderate erosion. Flashboard system serviceable
Current Pool Elevation	162.2 on 6/6; 162.0 on 6/28
Maximum Impoundment to Date	Unknown
Surface Cracks	Noted dampness at several construction joints
Pavement Condition	Severe spalling over all concrete surfaces. Some shrubbery growing from joints near tailwater
Movement or Settlement of Crest	None detectable
Lateral Movement	None detectable
Vertical Alignment	OK
Horizontal Alignment	OK
Condition at Abutment and at Concrete Structures	Both spillway abutments severely eroded
Indication of Movement of Structural Items on Slopes	None
Trespassing on Slopes	Yes - damage to Gate House & railings
Sloughing or Erosion of Slopes or Abutments	Seep located at downstream base of west embankment
Rock Slope Protection-Riprap Failures	Riprap in good condition - no failures
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Seep - see above
Piping or Boils	None observed
Foundation Drainage Features	See below
Toe Drains	Located 8" toe drain outfall just below gate house, not shown on construction plans
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 and 6/28/78

PROJECT FEATURE Embankment on west (right) end. NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	OK
Current Pool Elevation	162.2 on 6/6; 162.0 on 6/28
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	No pavement
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	OK
Horizontal Alignment	OK
Condition at Abutment and at Concrete Structures	Seep at toe of slope where embankment meets main concrete section
Indications of Movement of Structural Items on Slopes	No structural items on slope
Trespassing on Slopes	Footpath eroded along downstream slope of embankment at its contact with main concrete section.
Sloughing or Erosion of Slopes or Abutments	Seep - see above
Rock Slope Protection-Riprap Failures	Riprap in good condition - no failures
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	Seep - see above
Piping or Boils	None
Foundation Drainage Features	See below
Toe Drains	8" outfall located
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE Embankment on east (left) end NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	
Crest Elevation	Footpath on top
Current Pool Elevation	162.2 on 6/6; 162.0 on 6/28
Maximum Impoundment to Date	Unknown
Surface Cracks	None
Pavement Condition	No pavement
Movement or Settlement of Crest	None
Lateral Movement	None
Vertical Alignment	OK
Horizontal Alignment	OK
Condition at Abutment and at Concrete Structures	OK
Indications of Movement of Structural Items on Slopes	No structural items on slope
Trespassing on Slopes	Yes - but no damage
Sloughing or Erosion of Slopes or Abutments	None
Rock Slope Protection-Riprap Failures	Riprap in good condition, except for moderate growth of shrubbery
Unusual Movement or Cracking at or near Toes	None
Unusual Embankment or Downstream Seepage	None
Piping or Boils	None
Foundation Drainage Features	N/A
Toe Drains	N/A
Instrumentation System	None

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE Intake works NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	No intake channel as such - intake portals not inspected - totally submerged.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE _____ NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-CONTROL TOWER	
a. Concrete and Structural	
General Condition	Severe surface spalling, as on rest of dam
Condition of Joints	Worse than general surface - some damp
Spalling	Severe
Visible Reinforcing	Some exposed - probably from unsuccessful gunite treatment in '39
Rusting or Staining of Concrete	OK
Any Seepage or Efflorescence	Some damp joints
Joint Alignment	OK
Unusual Seepage or Leaks in Gate Chamber	Vandalism extensive - door torn off, Windows missing, roof damage
Cracks	None
Rusting or Corrosion of Steel	Very little steel
b. Mechanical and Electrical	
Air Vents	None
Float Wells	N/A
Crane Hoist	None
Elevator	None
Hydraulic System	None
Service Gates	Upper gate operable - custodian declined to operate other two - have fallen into disuse
Lightining Protection System	N/A
Emergency Power System	Hand operated - no power needed
Wiring and Lighting System in Gate Chamber	No electricity

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE _____ NAME Entire Party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-TRANSITION AND CONDUIT	The outlet pipe which is operable is rusty, but it works, and leaks only a trickle when shut.
General Condition of Concrete	Lowest outlet pipe is half silted in
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignments of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	No outlet channel as such - conduit discharge directly to natural stream bed.
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	
Channel	
Loose Rock or Trees Overhanging Channel	
Condition of Discharge Channel	

PERIODIC INS ECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE Spillway NAME Entire party

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	No approach channel - spillway is an integral part of the dam
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	Spillway has moderate erosion - training wall has severe erosion and spalling
Rust or Staining	Spalling too severe to notice rust or staining
Spalling	Severe on training walls
Any Visible Reinforcing	No
Any Seepage or Efflorescence	Too wet to notice
Drain Holes	None
c. Discharge Channel	No discharge channel - spillway built on ledge, which falls to natural channel
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

PERIODIC INSPECTION CHECK LIST

PROJECT Wheeler Dam DATE 6/6/78 & 6/28/78

PROJECT FEATURE _____ NAME _____

DISCIPLINE _____ NAME _____

AREA EVALUATED	CONDITION
OUTLET WORKS-SERVICE BRIDGE	
a. Super Structure	No service bridge - gate house integral with dam
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Memebers	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

WHEELER DAM

INDEX TO ENGINEERING DATA

Plate with Plan, Profile and Sections

N.H. Water Resources Board inspection memo, 12/22/77

N.H. Water Resources Board Dam Safety Inspection Report Form, 12/3/73

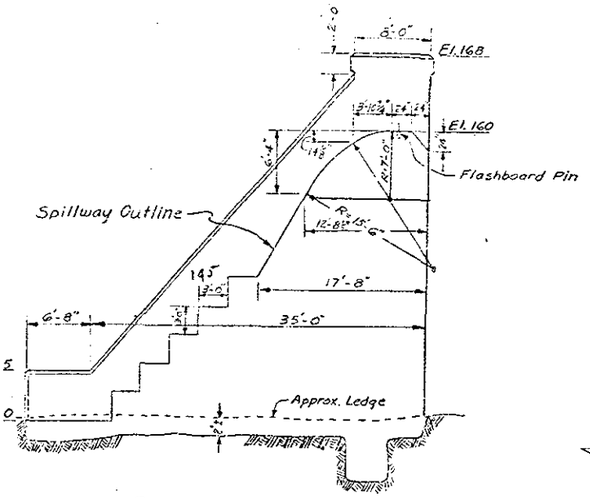
Report on concrete problems by Chas. T. Main, 9/19/63

Drawdown Curve

Photographs, 10/30/35

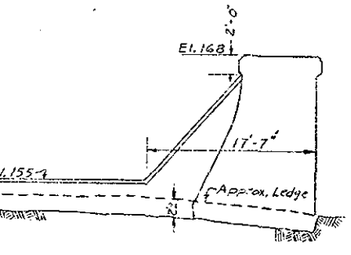
Construction Photographs - 3 pp.

Chief Engineer's Design Memorandum, 7/31/20



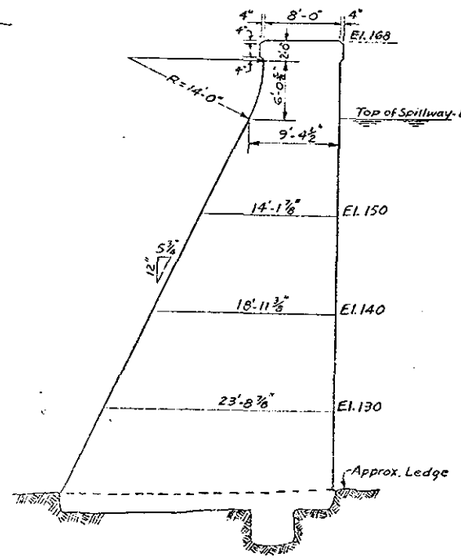
WEST WING WALL
ELEVATION.

SEE BAR SCALE BELOW



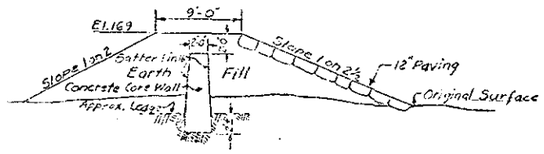
EAST WING WALL
ELEVATION

SEE BAR SCALE BELOW



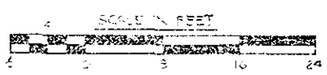
SECTION OF BULKHEAD

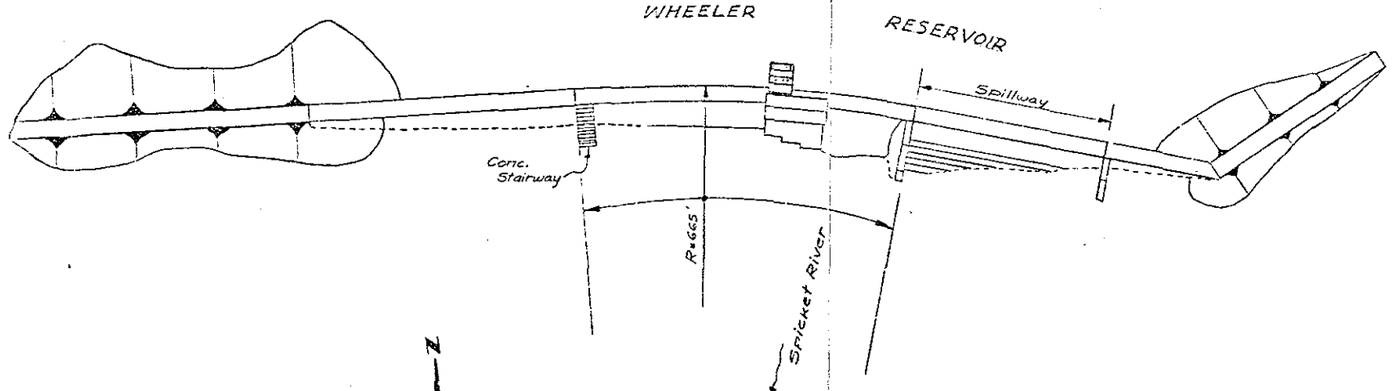
SEE BAR SCALE BELOW



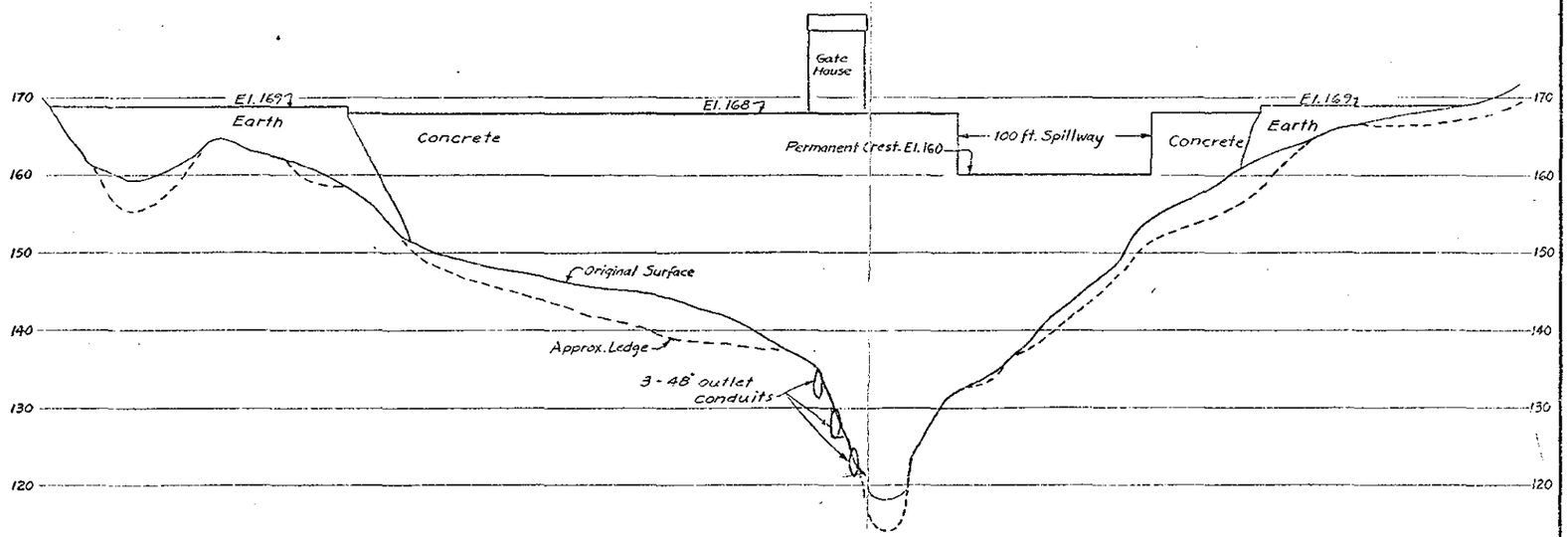
SECTION AT EAST AND WEST ENDS OF DAM

SEE BAR SCALE BELOW





PLAN OF DAM



All elevations are USGS mean sea level datum.

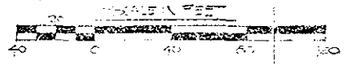
Traced from print of original plan dated July 1920, modified to suit

PROFILE OF DAM

Note:

All elevations are USGS mean sea level datum.
Traced from print of original plan dated July 1920, modified to suit.

HOR. SCALE



VERT SCALE = 1 EXAGGERATION

WHITMAN & HOWARD INC.
ENGINEERS AND ARCHITECTS
WELLESLEY, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

WHEELER DAM
ARLINGTON MILL RESERVOIR

SPICKETT RIVER NEW HAMPSHIRE

SCALE AS SHOWN
DATE JULY 1978

Greater Lawrence Industrial Corporation
550 Broadway
Lawrence, MA 01840

RE: REQUIRED REPAIRS TO THE FOLLOWING DAMS:

Dam #209.02 (Taylor Dam)

1. Repair abutments.
2. Repair badly eroded floor of chute spillway.

Dam #209.04 (Dike)

1. Remove trees which have started growing on dike.

Dam #209.05 (Wheeler Reservoir)

1. Repair leakage through dam located near gate house.
2. Repair spalling concrete before it becomes critical.

Dam #209.08 Millville)

1. Repair badly spalled and cracked abutments.
2. Repair leakage at location where new concrete has been added (Left spillway)
3. Remove trees and brush from downstream toe and dike.
4. Replace left gate stem.

Dam #209.09 (Canobie Lake)

1. Repair spillway - walls show signs of deterioration.
2. Remove trees from embankment.

zd/js

N. H. WATER RESOURCES BOARD
Concord, N. H. 03301

DAM SAFETY INSPECTION REPORT FORM

Town: SALEM Dam Number: 209.05

Inspected by: ZJD Date: 12-3 1973

Local name of dam or water body: SPICKETT RIVER

Owner: SPICKETT POND CORP Address: _____

Owner was/~~was not~~/interviewed during inspection.

Drainage Area: _____ sq. mi. Stream: _____

Pond Area: _____ Acre, Storage _____ Ac-Ft. Max. Head _____ Ft.

Foundation: Type LEDGE, Seepage present at toe /Yes/~~No~~, m.

Spillway: Type CONCRETE, Freeboard over perm. crest: 8',

Width 100', Flashboard height 2.1',

Max. Capacity _____ c.f.s.

Embankment: Type EARTH, Cover Rip Rap Width _____,

Upstream slope _____ to 1; Downstream slope _____ to 1

Abutments: Type Concrete, Condition: Good, Fair, /Poor/

Gates or Pond Drain: Size _____ Capacity _____ Type _____

Lifting apparatus _____ Operational condition _____

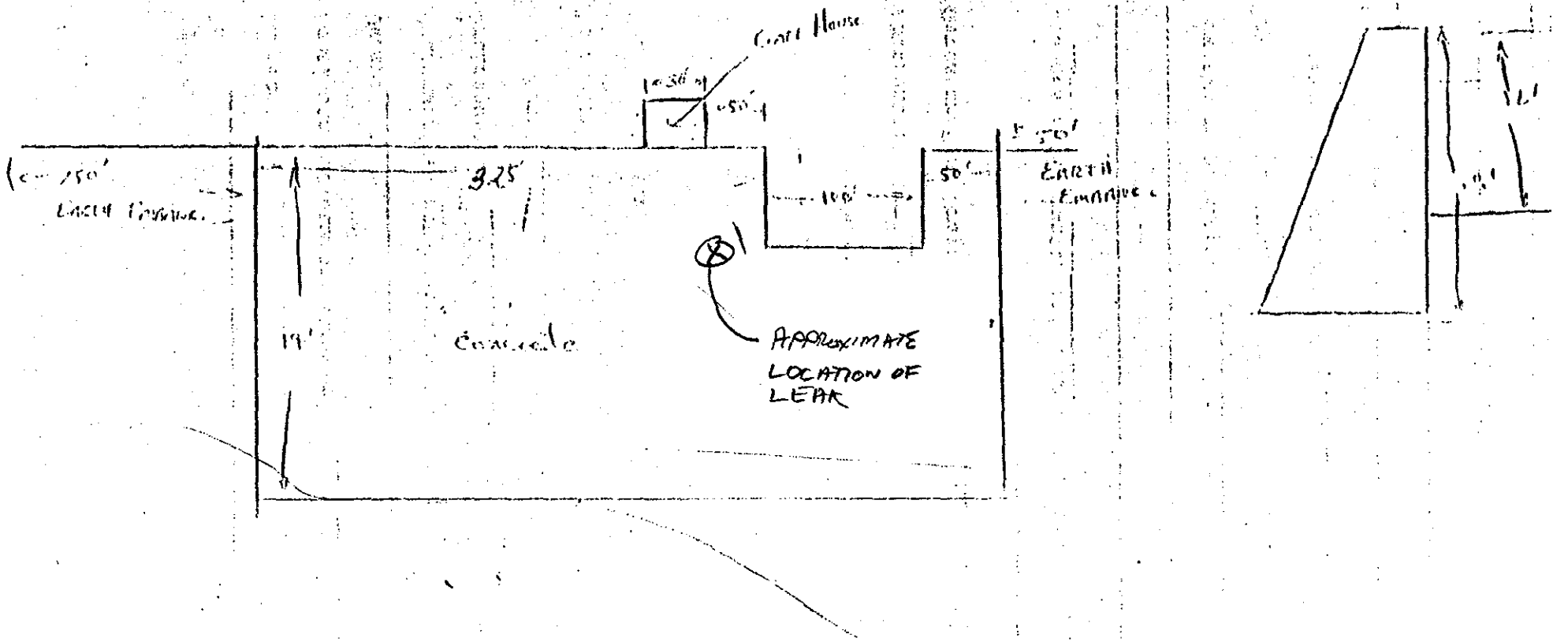
Changes since construction or last inspection: _____

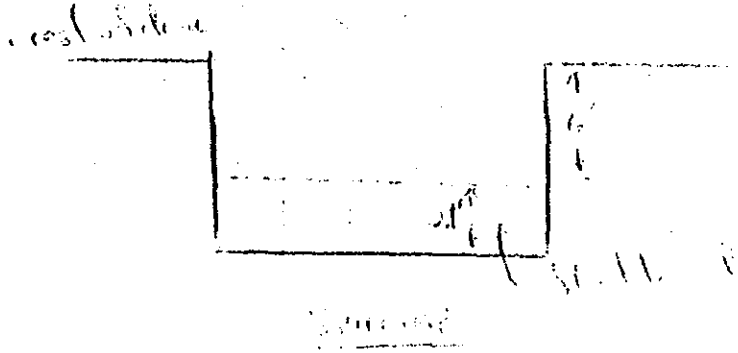
Downstream development: _____

This dam /would/~~would not~~ be a menace if it failed.

Suggested reinspection date: _____

Remarks: Concrete is badly spalled ____ ft around expansion joints (no change since last inspection) - leaking through concrete see detail. Trees have started growing in Embankment


Earth Embankment
325'
Concrete
APPROXIMATE LOCATION OF LEAK
Earth Embankment



CHAS. T. MAIN, INC.
80 FEDERAL STREET
BOSTON 10, MASS.

INDUSTRIAL PLANTS
TEXTILE MILLS
PAPER MILLS
PRINTING PLANTS
STEAM POWER
WATER POWER
FOUNDATIONS
VALUATIONS

CABLE ADDRESS
CHASMAIN, BOSTON

129 WEST TRADE STREET
CHARLOTTE 2, N. C.

September 19, 1963

2177-2

Report caused by letter of 8/13/63

Subject: Wheeler and Millville Dams

Mr. Loring Reed, President
Spicket River Corporation
600 Broadway
Lawrence, Massachusetts

Dear Mr. Reed:

The writer inspected the Spicket River Corporation's Wheeler Reservoir Dam and Millville Reservoir Dam on September 17, 1963, in your company and that of Mr. Farrell, the property superintendant. The purpose of the inspection was to investigate the safety of these structures and any remedial measures that might presently be required. We also took note of the measures requested by the New Hampshire Water Resources Board in their letter to you of August 13, 1963.

The following summarizes our findings, based on the inspection and a review of the original construction plans.

Wheeler Reservoir Dam.

This structure is a solid gravity concrete dam with earth embankment wings. The concrete portion contains a standard ogee spillway, 100 feet long, flanked by non-overflow bulkhead sections. The bulkhead contains a sluice gate section for drawing on the reservoir. The maximum height is about 50 feet but the general average height is about 30 feet. There are two saddle dike embankments, designated East Dike and West Dike with maximum heights of about 30 feet and 10 feet respectively. All embankments have concrete core walls. Pertinent elevations are: crest of spillway--Elev. 160, top of bulkheads--Elev. 160, top of embankments--Elev. 160. The structure was designed by Professor H. K. Barrows, an eminent engineer of his time. It was constructed in 1922.

West D doesn't

At the time of inspection the reservoir was at Elev. 154, or 6.0 feet below the spillway crest.

1. The structure shows surface deterioration that might be expected. The downstream face has generally spalled. A good number of the horizontal construction joints have raveled, extending back as much as 8 inches from the original surface. The top of the bulkheads have spalled rather badly, particularly along the downstream edge. The upstream face is generally in very good condition, except for one horizontal joint adjacent to the spillway which has ravelled back along the length of a block and a vertical contraction joint. In sum, the deterioration is almost universally prevalent in structures of this age and reflects the construction methods employed at the time.

In our opinion--and this was confirmed by stability computations based on the original design dimensions--the above noted conditions do not jeopardize the safety and stability of the structure.

The deterioration will continue, however. Certain measures have been tried in an attempt to halt similar deterioration, such as coating with an epoxy, but have not been particularly successful. At one time, a good portion of the downstream face of the bulkheads was coated with gunite. This has loosened and fallen away in patches, a condition which is largely responsible for the unsightly appearance. We recommend that this treatment not be repeated. It would add nothing to the strength of the dam and, as has been shown here as well as elsewhere, would not be permanent.

We would not like to see the surface spalling and ravelling extend further than 18 inches from the original surface at any point before corrective measures are taken. This applies particularly to the downstream face and most particularly, to the lower portion of the deepest section adjacent to the spillway. No accurate forecast can be made as to the length of time this might take--it might be another 40 years but it might be considerably less. We therefore recommend that periodic inspections be made and any significant changes noted. At some time in the not too distant future, a detailed survey should be made so that the critical areas can be measured and plotted accurately, followed by a mathematical analysis.

2. The embankment sections appear to be in good condition, well riprapped and with no evidence of sloughing. Some small trees and brush have, however, grown up on the slopes and these should be removed. We understand that you have done this periodically in the past and expect to do so again this fall, followed by chemical treatment of any new growth next spring. We concur in this and recommend that the program be maintained. Grass or small growth should, of course, be left so as to protect the banks from wash.

3. The Water Resources Board has requested that the present flashboards be removed and that the proposed design be submitted for approval.

The original design of the dam called for 12 inch high boards, with 1 1/8" dia. pins, 7'0" on centers. We compute that these would have failed when the reservoir reached somewhere between Elev. 163.5 and 164.9.

Your present boards are 2'0" high, with pins 2'4" on centers. Some of the pins are 1" dia., others are 1 1/4" dia. but a good number of these are old and have lost a part of their section. We compute that the present boards would start to fail when the reservoir reached Elev. 164 and would be all out at reservoir Elev. 166. At that point there would be 3 feet freeboard on the dikes. We consider this a reasonable design.

We therefore suggest that you request the Board to consider approval of the present installation. If this is not satisfactory we suggest that you request approval for substituting 1" double extra-strong pipe (1.315 O.D.) for the 1 1/4" dia. pins. We compute that these would fail with reservoir at approximately Elev. 164.5. It appears that the original design of the dam was based on maximum reservoir Elev. 165.

We recommend that you maintain your present practice of drawing the reservoir as much as possible upon receipt of a tropical hurricane warning or other potential source of a flood, and keeping the sluice gate open during the flood discharge. This will add to the safety of the dam during floods, which is the most critical period.

4. The Water Resources Board has requested maintenance of the small gaging station dam, downstream from the main dam, along with the main dam. This structure now appears to be in excellent condition except for 2 or 3 trees that have grown up between the wing walls and the banks. We understand that you will have these removed. In our opinion, however, this small structure is not a hazard and serves no useful purpose unless it might at some future time be re-established as a gaging station.

Millville Reservoir Dam.

This structure is a solid concrete spillway dam, tieing into the hillside on the south bank and flanked by a wingwall and an earth embankment at the north end. The embankment has a concrete

We infer from the body of the Water Resources Board's letter of August 13, 1963, that the word "menace" is used as a standard characterization of any dam above a built-up area, implying potential rather than present danger. This, of course, is proper.

Very truly yours,

CHAS. T. MAIN, INC.

By C. C. Cullum

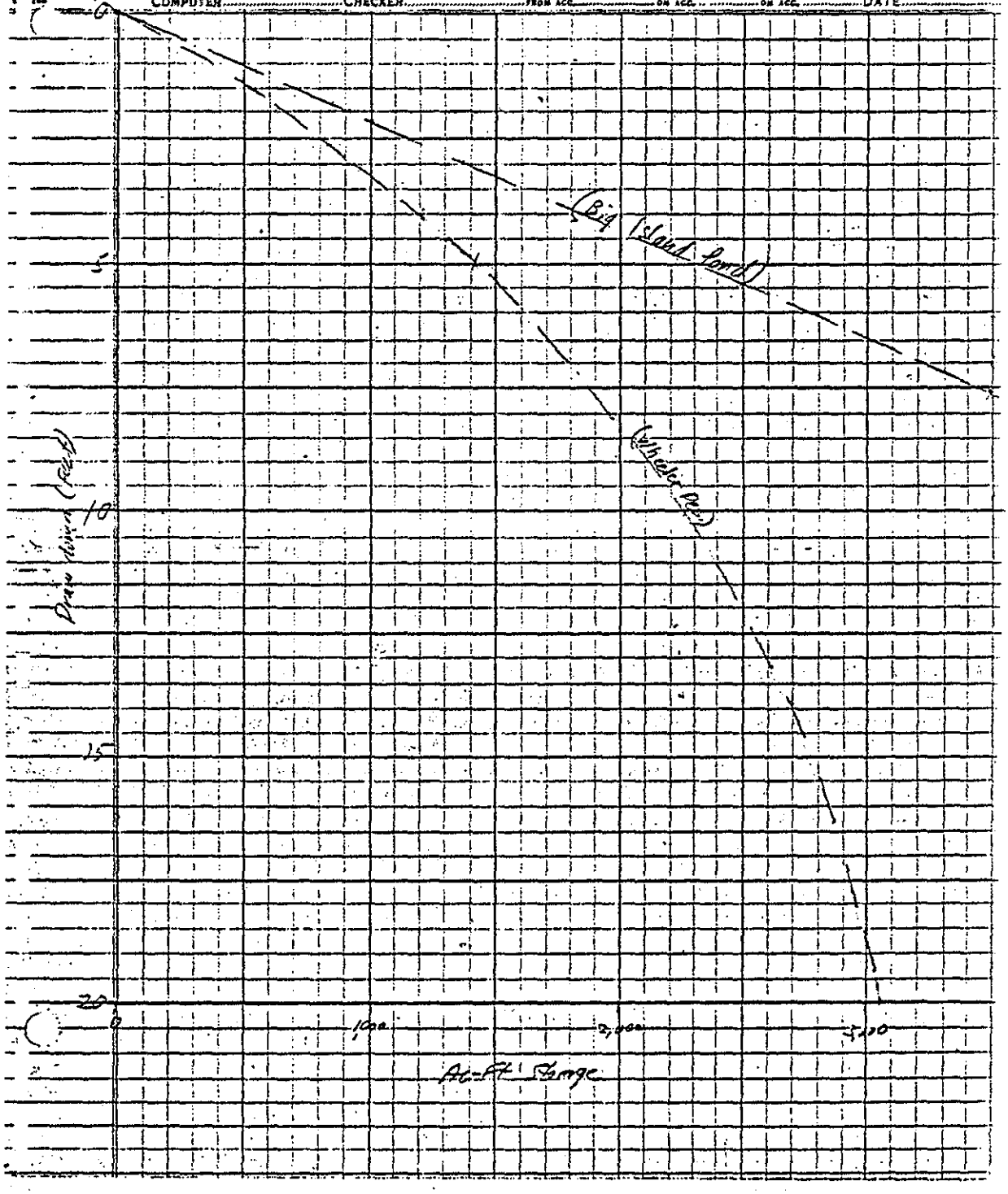
C. C. Cullum

CCC/jp

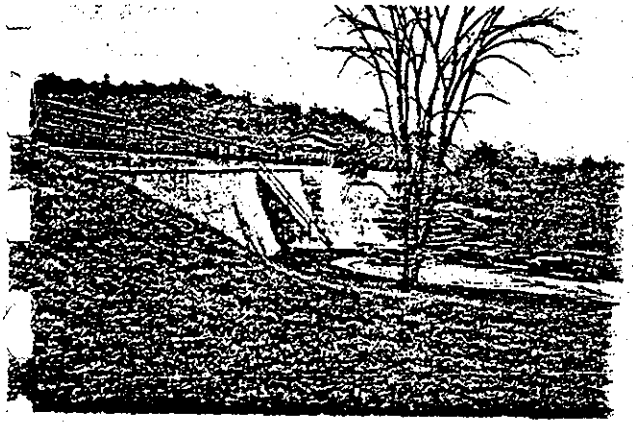
TER RESOURCES
BOARD
CONCORD, N. H.

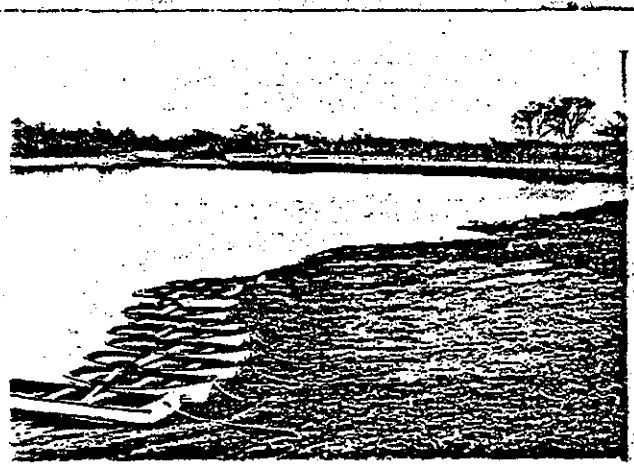
SUBJECT ..... Acc. .....

COMPUTER ..... CHECKER ..... CONT. FROM ACC. ..... CONT. ON ACC. ..... SUMMARY ON ACC. ..... DATE .....

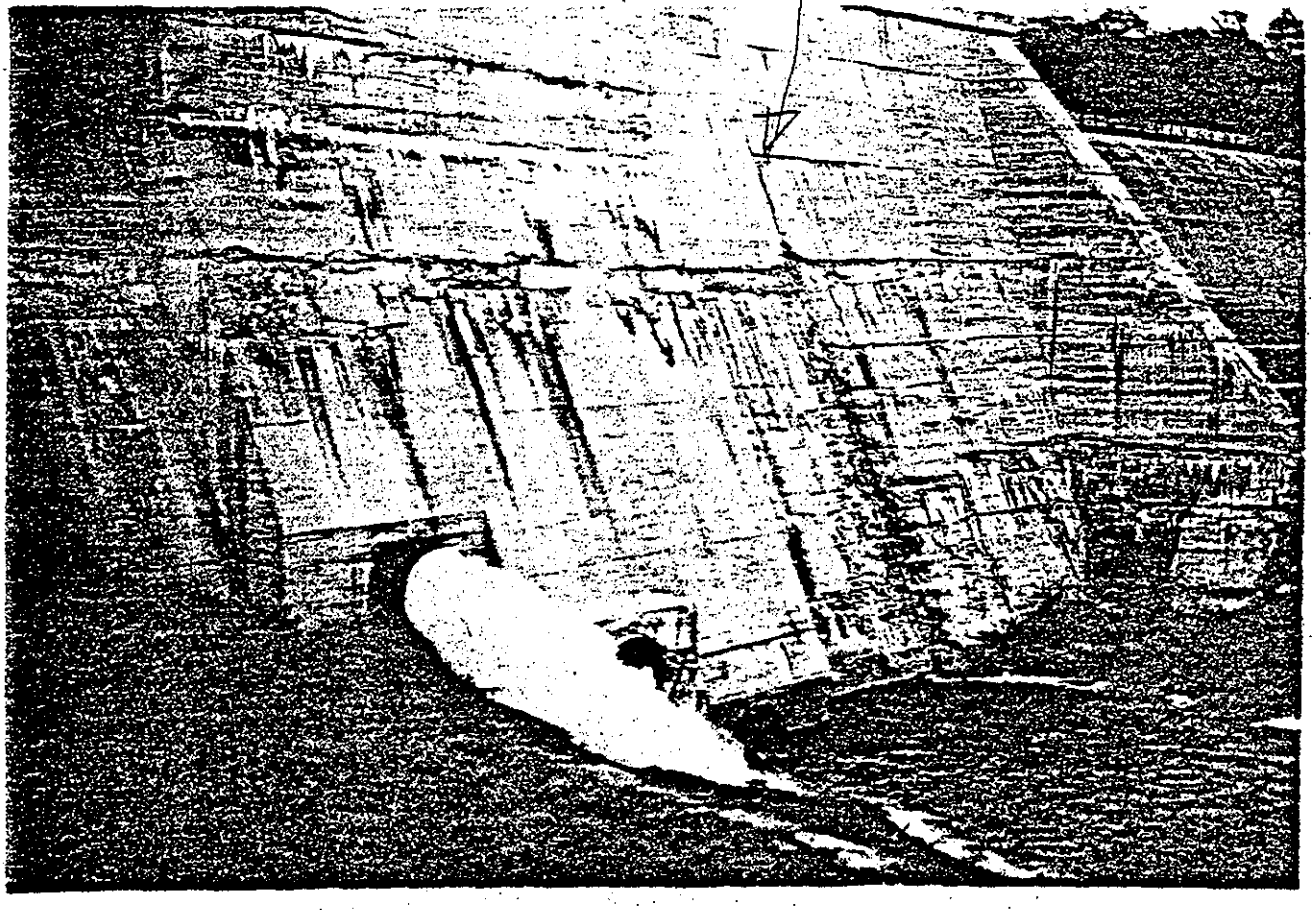


SPICKETT RIVER IN SALEM
Arlington Mills
October 30 1935





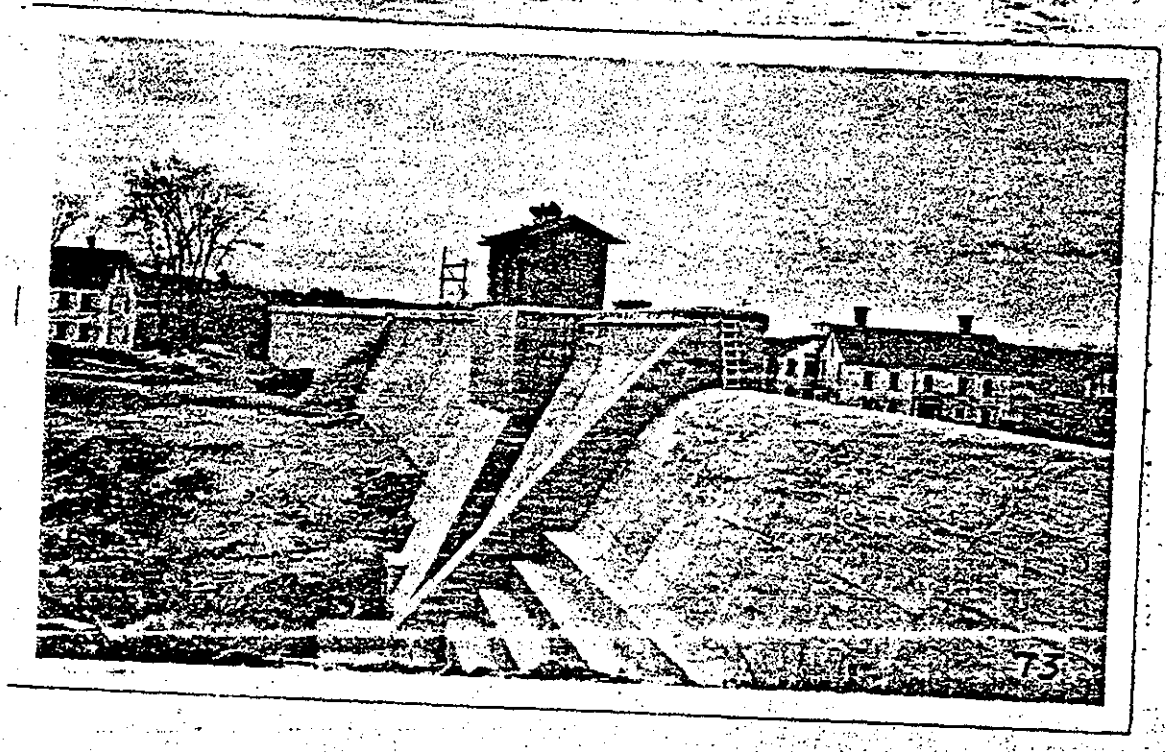
NOTE SPALLING AFTER 13 YEARS

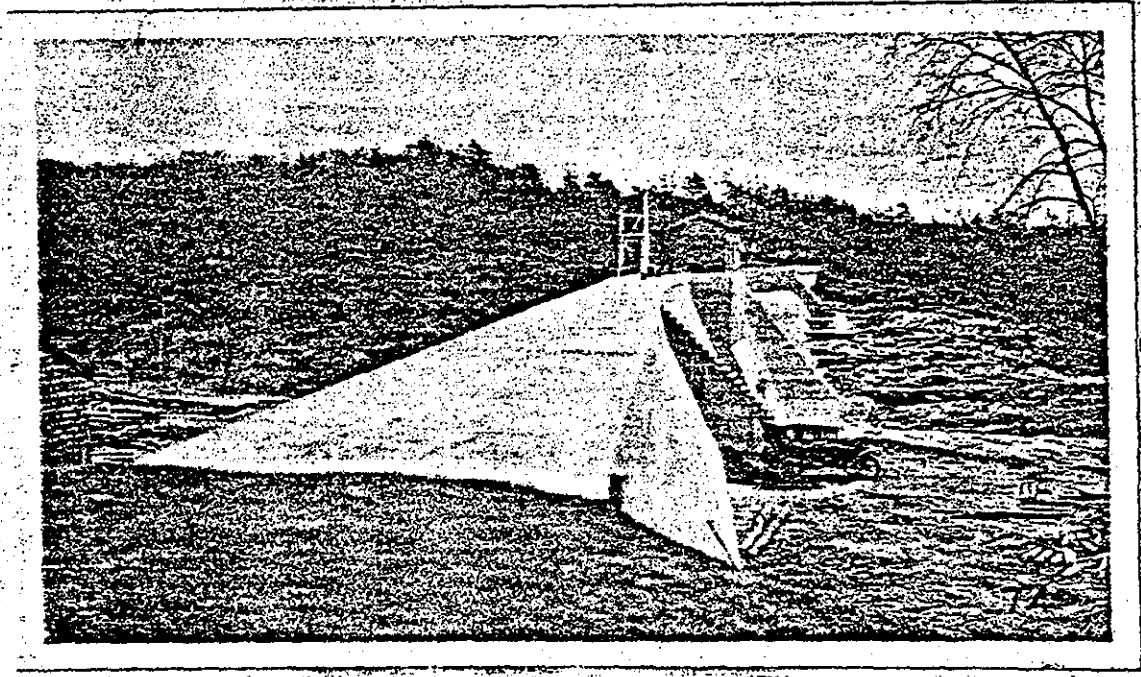


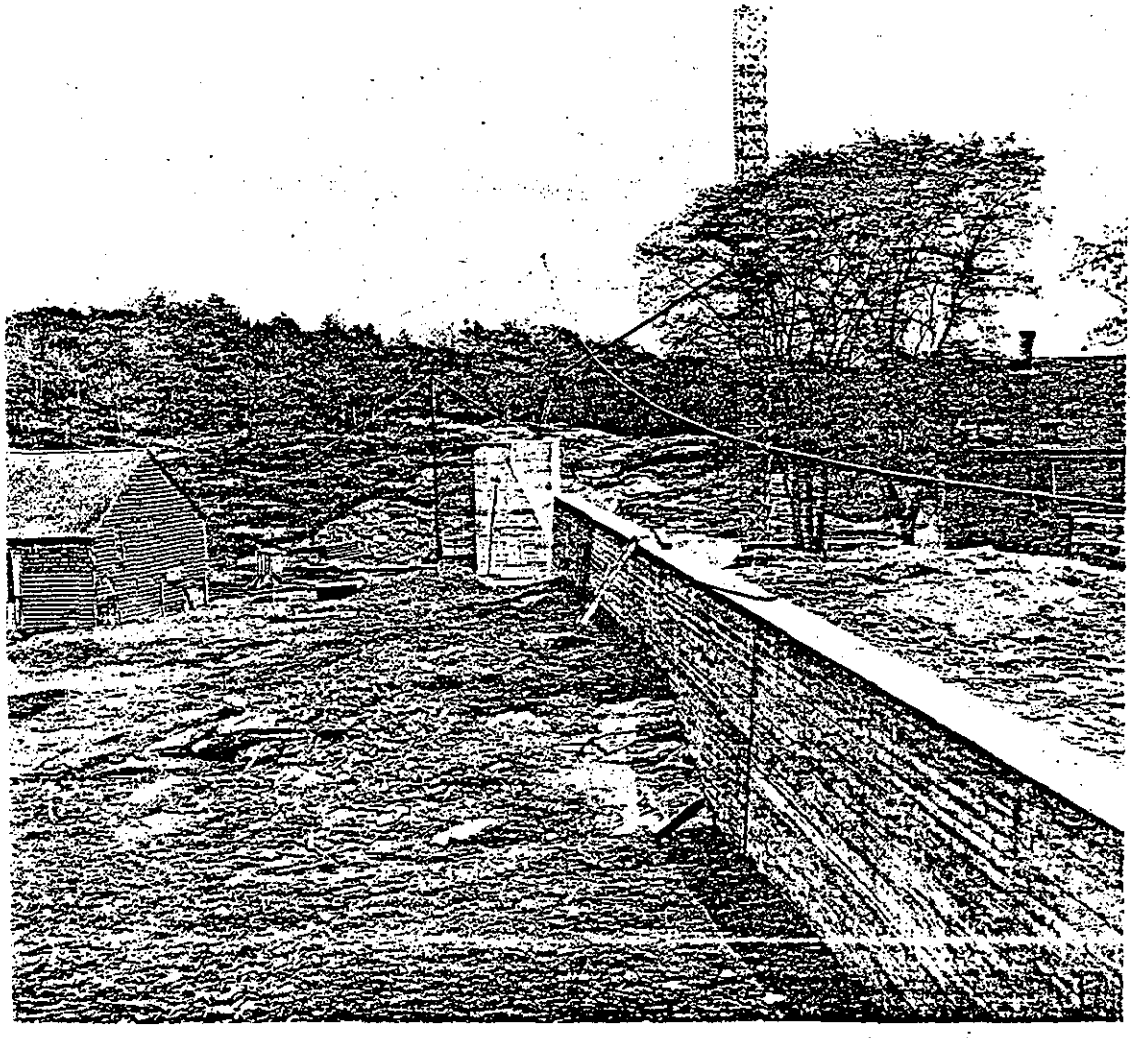
~~NO. 299.02~~
209.05

Construction Photos

ARLINGTON MILLS RESERVOIR
SALEM







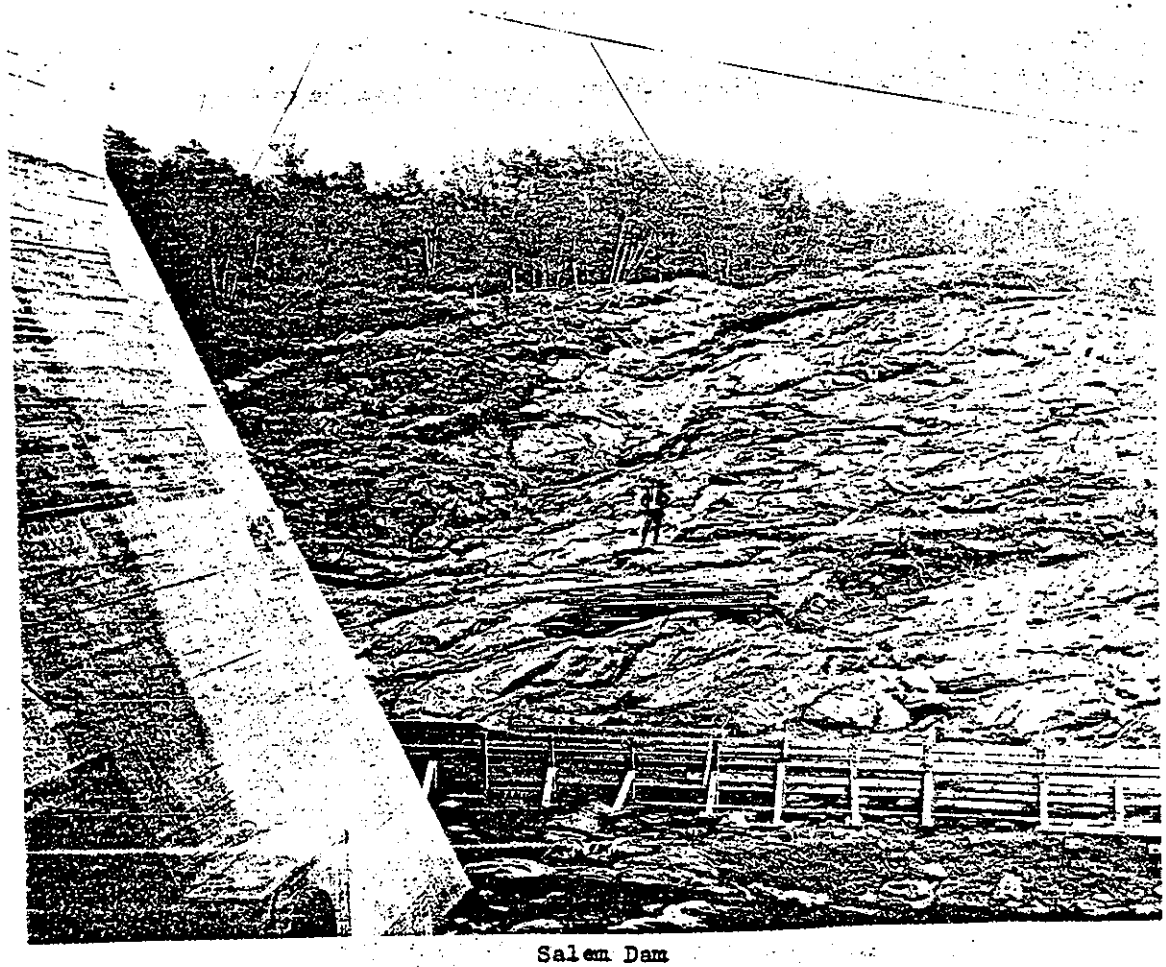
Salem Dam
of the
Arlington Mills of Lawrence, Mass.

General View of Main Dam

View from east side looking along line of dam showing gate section, cut-off and concrete pouring tower.

Under the direction of the
Public Service Commission of N. H.

May 21, 1922.



Salem Dam

of the

Arlington Mills of Lawrence, Mass.

Main Dam

Line of base shown by dotted line.

Uncovered ledge - east side.

Gate section all in place.

Under the direction of the

Public Service Commission of N. H.

May 21, 1922.

H. K. BARROWS
M. AM. SOC. C. E.
CONSULTING ENGINEER
6 BEACON STREET
BOSTON

ARLINGTON MILLS WATER SUPPLY

WHEELER RESERVOIR

Memorandum by H. K. Barrows, July 31, 1920, accompanying letter to N.H. Public Service Commission.

WHEELER RESERVOIR

The general extent of this reservoir is shown on sheet 1019.45. It is located on Spicket River in the town of Salem and will extend from the vicinity of Wheeler's Mill (burned a number of years ago and not rebuilt) to North Salem - a distance of about 1.5 miles. The drainage area of Spicket River tributary to this reservoir will be about 22 square miles.

As planned, the level of the permanent spillway of the main dam will be at elevation 160 (datum approximate mean sea level) and the capacity of the reservoir when drawn to elevation 140 will be about 1,000 million gallons. The elevation of the present mill pond at the old Wheeler Mill is about 133. As noted further, it is planned to arrange the spillway of the main dam so that 1 ft. flash-boards can be carried if desired, which will increase the capacity of the reservoir above elevation 140 to a total of about 1,100 million gallons.

The water area of the reservoir at elevation 160 will be about 270 acres.

CONSTRUCTION REQUIRED

In addition to the main dam near the old Wheeler Mill, there will be required two dikes at low places in the watershed. These are shown on sheet 1019.47 as the East and West Dikes respectively.

Borings and test pits have been made and ledge rock located at both dam and dike sites.

As will be noted, a section of the highway leading from Salem to North Salem is to be discontinued and in lieu of this a new road constructed lying easterly from the East Dike and connecting with existing roads, which are also to be reconstructed. The highway at North Salem will also have to be raised for a few hundred feet, and at at least one other point on the highway adjacent to the reservoir a slight fill made. These changes were authorized by the Town of Salem on July 10, 1920.

MAIN DAM

Details of the main dam are shown on sheet 1019.46. Its total length will be about 730 feet, consisting of a 100 ft. spillway at El. 160, and about 380 ft. of bulkhead section, all of concrete. The interior portion of the concrete will be in the proportion of 1-3-6, with occassional large stones embedded in the concrete. tThe exterior portion of the concrete are to be in the proportion of 1-2½-4. The remaining portion of the dam at each end will consist of earth fill with concrete core wall, the concrete to be 1-3-6.

The maximum height of the spillway section is about 28 ft. above ledge rock with crest at El. 160, arranged so that 12 inch wooden flashboards can be carried by wrought iron pins. The latter are proportioned so that they will bend over and the flashboards go out if the head of water on the crest of the dam reaches 4 ft.

The bulkhead section will have a maximum height above bed rock at the present river bed of about 53 ft. The bulkhead section for a length of 160 ft. near its highest portion will be curved upstream in plan, with a radius, on the downstream side, of about 665 ft.

In the bulkhead section is to be a gate house through which will run three 48 inch steel pipes set in the concrete of the dam, each arranged with a 48 inch circular sluice gate with gate control and lift in the gate house at the top of the dam. The westerly pipe is intended for power use of water, is to be arranged with racks and can be later extended down stream a short distance to a suitable power house location. The other two 48 inch pipes are intended for use in releasing water from the reservoir. ← Never done

DIKES (See sheet 1019.47)

East Dike

The East Dike will be about 530 ft. long constructed of earth fill with concrete core wall. The top of the dike will be at El. 169, the top of core wall 167. The upstream

half of the dam is to be of impervious earth fill carefully rolled, the downstream half of less carefully selected material but well compacted. The concrete core wall is to be in the proportion of 1-3-6 and to extend into ledge or impervious foundation. Further details are shown on the plan.

The maximum height of the East Dike above the present surface is about 31 ft.

West Dike

As will be noted by reference to sheet 1019.47, this is a low structure, the present ground level being only a little below El. 160 at the middle of the dike location. The maximum height of the dike with top at El. 169 is about 10 ft. This will be of earth fill, as noted on the plan, but without concrete core.

APPENDIX C

WHEELER DAM

INDEX TO INSPECTION PHOTOGRAPHS

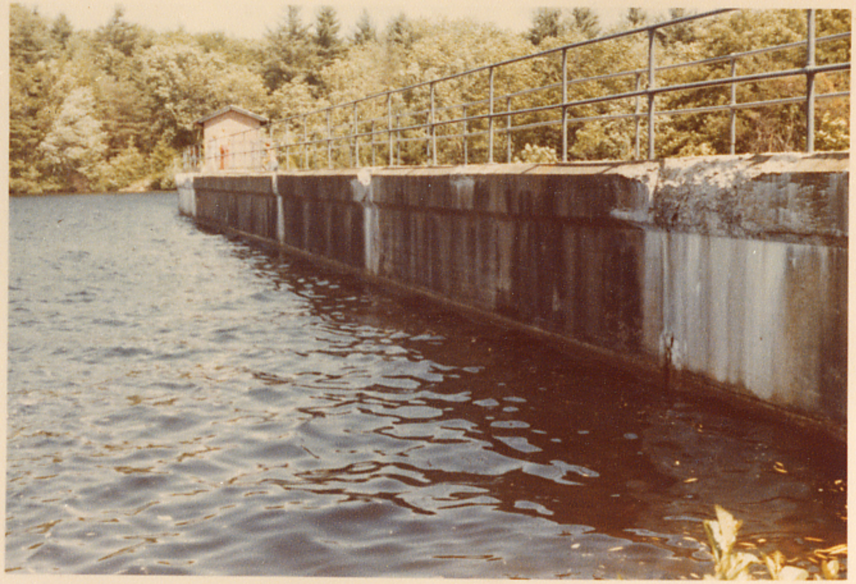
Photo No.	Description
1	View from east abutment along crest.
2	View from west abutment showing: crest of embankment section (in foreground), crest of concrete section and gatehouse (in background), upstream slope of embankment section with some brush, and downstream slope covered with grass and area downstream of toe of embankment section covered with trees and brush.
3	Area downstream of concrete-gravity section seen from crest of east end of west embankment. Seepage shown on Photo 9 is about half-way down the earth slope along the downstream face at the west end of the concrete-gravity section.
4	View of upstream face of concrete gravity section looking east from west end of concrete-gravity section.
5	Dampness in vertical construction joint west of gate house on downstream face. Note severe general spalling.
6	Spalling and loose concrete on downstream face. Gate house concrete section shown on right. Loose concrete appears to be a result of unsuccessful gunite application.
7	Three outlet conduits. Note extreme spalling, silted-in bottom outlet, and brush growing in joints in background.
8	Upstream face of embankment section at west end of dam looking toward west abutment from west end of concrete-gravity section. Riprap on upstream face, some brush growing on upstream face.

Photo No.	Description
9	Seepage at the downstream side of the western end of the concrete-gravity section of the dam. Six-foot rule for scale in upper left of photo.
10	Eroded footpath looking down the same slope shown in the foreground of Photo 9.
11	Looking west toward toe-drain pipe near base of concrete section at the west bank of the downstream channel. Small discharge of water. Pipe is beneath the left end of the six-foot rule.
12	Trees growing from deteriorated concrete in downstream face of concrete-gravity section between gatehouse and overflow spillway. Shown in background of photo 7.

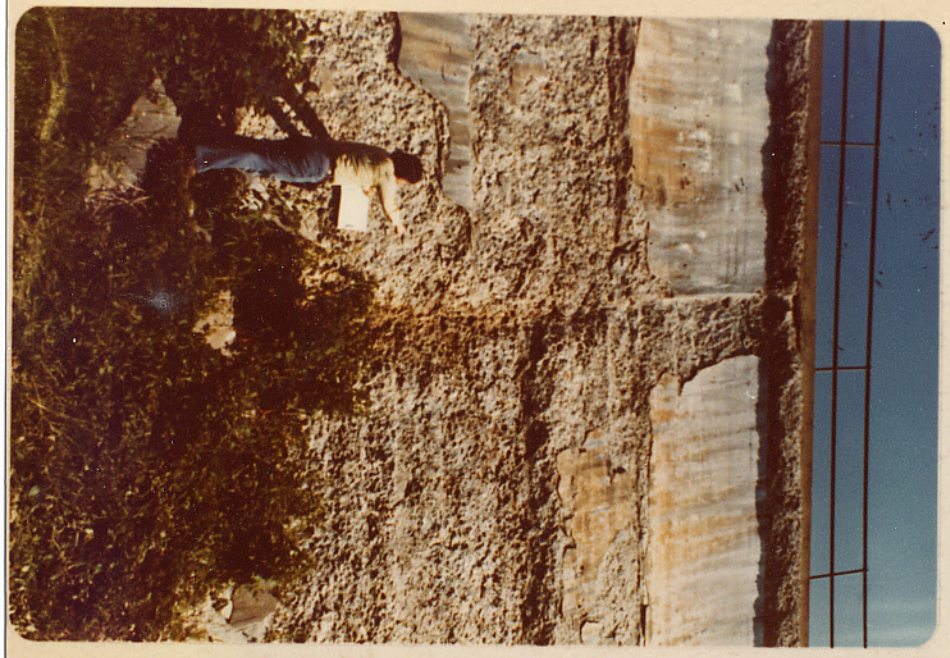
1

2

3



4



5

6

7

8

9

10

11

12

APPENDIX D

HYDROLOGIC COMPUTATIONS

WATERSHED MAP

APPENDIX D

BY T.I.C DATE Aug. 78 PROJECT Army Corps Engrs SHEET NO. 1 OF 7

CHKD. BY DATE Dam Safty Inspection JOB NO. 8-081, 082, 083

Arlington Mill Reservoir

East Dike	1922	31'
Wheeler Dam	1917	32'
West Dike	1922	10'

I. Hydrology & Hydraulic Data.

a) Drainage Area = At Dam site D.A is 23.5 sq. mile includes Big Island Pond D.A of 16.7 sq. mile

b) Watershed Characteristics.

River channel Slope ≈ 0.0288 — Major Drainage Area

Side drainage area slope West ≈ 0.048

East ≈ 0.052

Big Island Pond discharges into Arlington Mill Reservoir, within a 23.5 sq. mile drainage area these are both good sized reservoirs. Therefore the Basin should be classfied as flat-rolling-land type.

c) Water surface Area = 266 Acres at El. 160± (Spillway Crest Elevation)

d) Storage Capacity: Based on N.H Water Resources Board: storage for the top 20 ft is about 3030 Acre-ft. Usually the Drawdown curve start at spillway crest. The top five feet has storage capacity of 1200 Acre-Ft, therefore, the estimated maximum storage should be about 5400 Acre-ft, (Normal storage would be about =400 Acre-ft.) This assumes that water surface would reach top of the concrete pation of the dam (El. 163) and the spillway crest (El. 160) respectively.

Therefore, All three embankments (Wheeler Dam, East Dike, West Dike) should be classified as intermediate dam category.

e) Probable Max. Flood Flow. Based on D.A = 23.5 sq. mile

Estimated Peak PMF for Rolling Land = 1400 cfs/sq. mile D.A
" Flat Area = 600 cfs/sq. mile D.A
Avererage = 950 cfs/sq. mile D.A.
Peak PMF = 950 x 23.5 = 22,325 cfs

f) Existing Spillway Capacity: Neglecting wave action

Top of Earth embankment at El. (169) 169
Top of Concrete Gravity Dam at El. 168
Spillway crest Elev. 160
Spillway length (Ogee Section) 100 Ft

Spillway Max. Capacity when Water at Top of Dam (El. 168)
$= 3.8 \times 100 \times 8^{3/2} = 8600$ cfs

But the concrete gravity section of Dam can be overtopping at about 1 ft during emergency; than the peak spilling capacity
$= 3.8 \times 100 \times 9^{3/2} + 335 \times 3.0 \times 1^{3/2}$
$= 10260 + 1005 = 11{,}265$ cfs $\simeq$ 1/2 Peak PMF

There are 3 - 4' diameter gates, only one operatable at present, the other two have not been operated for long time. Assume all three can be fixed and operated and use it as emergency spillway. the capacity of the 3 gates is:

$Q = \sqrt{\frac{40}{1.75}} \times 8.03 \times (3 \times 4 \times 3.14) = 1450$ cfs When tailwater lower than outlet.

40/1.75 This would bring the total emergency spillway capacity to about 12,600 cfs.

g) Discharge Flow Rating Curve.
The total length of earth embankments including main Dam, West Dike and East Dike is about 7010 ft in length. Treat it as abroad crested Weir with discha

Coefficient of 2.7 (Usually C = 2.67 to 3.05 for broad crested weir).

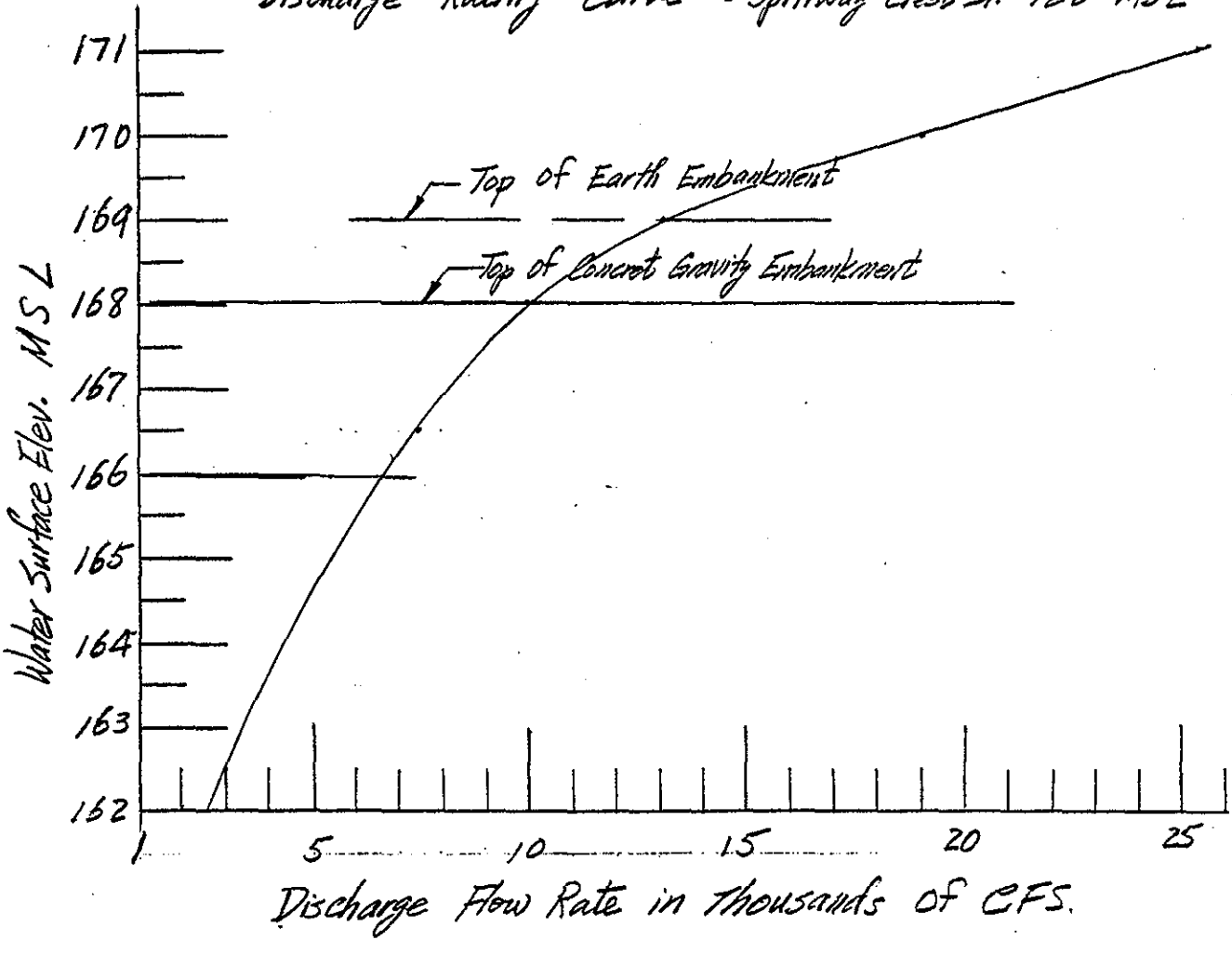
For water surface at level 1 ft above the top of earth embankment, discharge flow rate would be

$$Q = 3.8 \times 100 \times 10^{3/2} + 335 \times 3.0 \times 2^{3/2} + 1010 \times 2.67 + 1450$$
$$= 12,016 + 2843 + 2697 + 1450 = 19,006 \text{ cfs}$$

For water surface at level 2 ft above the top of earth embankment, discharge flow rate would be

$$Q = 12,016 (1.1)^{3/2} + 2843 \left(\tfrac{3}{2}\right)^{3/2} + 2697 (2)^{3/2} + 1450$$
$$= 13863 + 5223 + 4800 + 1450 = 25336 \text{ cfs}$$

Discharge Rating Curve = Spillway Crest El. 160 MSL



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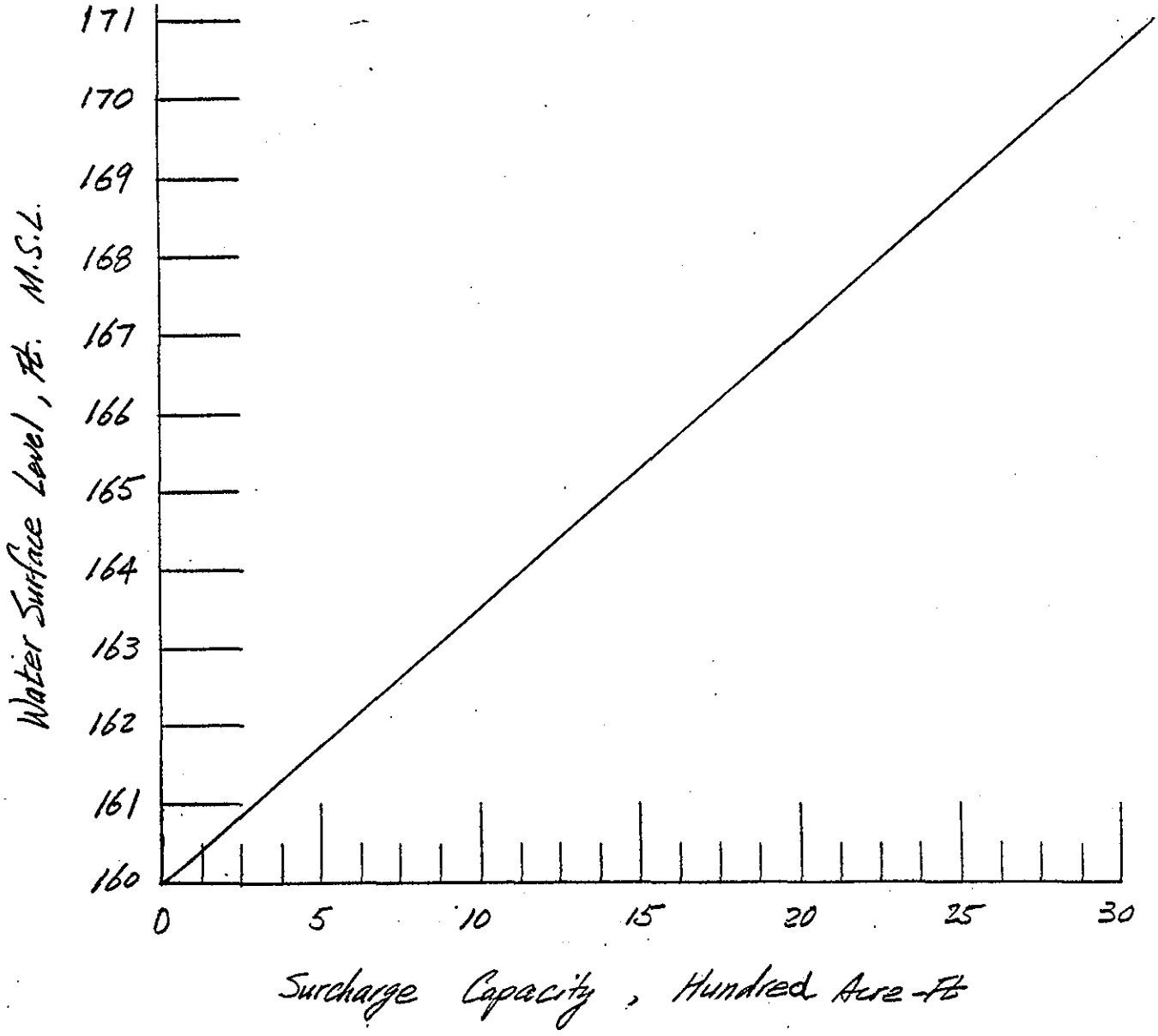
h) Surcharge Capacity (= Water Surface Area x Surcharge depth) and its effect



For QP1 = 22,330 cfs from discharge rating curve

$H_1 = 170.5 - 160 = 10.5$ Ft

$STOP_1 = 10.5 \times 266 \times 1.562 \times 10^{-3} \times 12/235$

$= 2.228$ inch

$QP2 = QP1\,(1 - 2.228/19) = 19,685$ cfs

$H_2 = 17.2 - 160 = 10.2$ Ft

$STOP_2 = 2.228\,(\frac{10.2}{10.5}) = 2.164$ inch

$STOP_{Ave} = (2.164 + 2.228)/2 = 2.196$ inch

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$Q_{P3} = Q_{P1}\left(1 - \frac{2.196}{19}\right) = 19{,}749$ cfs

$\therefore H = 170.3 - 160 = 10.3$ Ft About 1.3 Ft overtopping the earth embankment

i) Consider Big Island Pond Surcharge Effect.

If Big Island Pond Dam does NOT FAIL at peak PMF then, the discharge from Big Island Pond amount to 10,500 cfs.
Peak inflow from addition watershed $= 950(23.5 - 16.7)$
$= 6500$ cfs
Total peak inflow rate $= 17000$ cfs
Then by discharge rating curve, $H = 169.7 - 160 = 9.7$ Ft
$STOP_1 = 9.7 \times 266 \times 1562 \times 10^{-3} \times 12/23.5 = 2.06$ inch

$Q_{P2} = 17000\left(1 - \frac{2.06}{19}\right) = 15159$ cfs
$H_2 = 169.4 - 160 = 9.4$ Ft
$STOP_2 = 9.4 \times 2.06/9.7 = 2.0$ inch

$STOP_{Ave} = \frac{STOP_1 + STOP_2}{2} = 2.03$ inch

$Q_{P3} = 17000\left(1 - \frac{2.03}{19}\right) = 15184$ cfs, say 15200 cfs.
$H = 169.4 - 160 = 9.4$ Ft about 0.4 ft. overtopping the earth embankments (including dikes)

For any earth embankment, it should never be overtopped, especially without considering the wave effect. Therefore, increase the spillway length is necessary.

j) Improvement.

Assume an additional spillway at elevation 1.5 Ft higher than the existing spillway crest with length of 50 ft. then when water level at the top of concrete section of the dam, the total spillway capacity would be

$Q = 10260 + 3.8 \times 100 \times 7.5^{3/2} + 1450$
$= 10260 + 7805 + 1450 = 19515$ cfs

with surcharge effect, this additional spillway should be adequate.

Alternative: Based on my experience, probably the other economical alternative do to convert West dike into an additional spillway, that is change the road into bridge with, box culverts. Since the height of the west dike is only about 10 ft. it should be easier to convert it into a spillway than Wheeler Dam. Also, originally, the downstream side of the West Dike has a stream, so, the discharge channel still there. The Box Culvert should have a invert Elev. 161.5 ft. MSL. so that the flashboards still can be used. The width of the Box Culverts should be determined by detailed flood routing, the height of the Box should be at least 15 ft.

II Visual Inspection and Conclusions:

a) Arlington Mill Reservoir spillway's left retaining wall (Wing Wall) is not high enough, flood flow may over spill from top of the retaining wall and wash out some of the soil near the toe of the dam. Although, the effect on the safety of the dam may not be serious, it is suggested that some riprap should be placed to protect the earth surface.

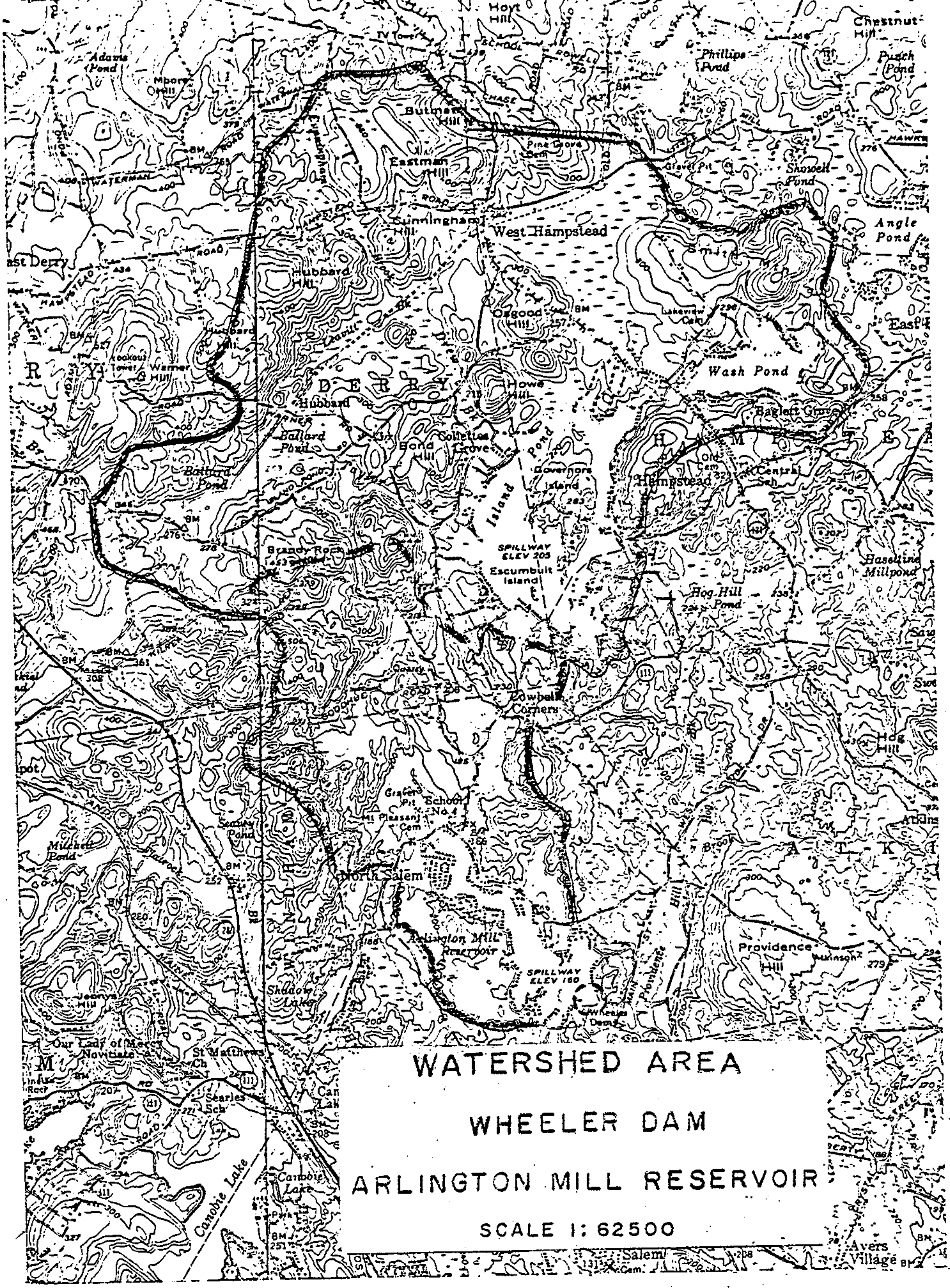
b) Arlington Mill Reservoir does not have enough spillway capacity to pass the peak inflow of PMF, even by neglecting wave effect and considering surcharge effect. Its normal capacity (with wave effect) only amounts to 6300 cfs and its maximum capacity (neglecting wave effect) amounts to 8600 cfs. Outlet conduits could discharge 1450 cfs. So, the max. total spillway capacity (includes outlet discharge) is about 10,050 cfs. By including one-foot surcharge, to use the concrete gravity section of the dam as additional spillway, it has combined maximum capacity of about 12,600 cfs. The peak inflow of PMF is about 22,330 cfs.

c) Of the three 4-ft diameter outlet conduits only one is operatable at present, the other two have not been used for a long time. If all three can be used as emergency spillway, it would have a capacity of 1400 – 1500 cfs.

d) By assuming that the Big Island Pond Dam would stand overtopping and not fail, its surcharge effect would reduce the peak inflow of PMF to Arlington Mill Reservoir from 22,330 cfs to 17,000 cfs, with the outlet conduits, and the reservoir surcharge, an additional spillway is still needed to prevent overtopping its earth embankment.

e) To provide adequate spillway capacity, an additional Ogee spillway with crest elevation at 161.5 M.S.L. with a length of 50 ft is needed.

f) It seems more economical to convert the West Dike into a box culvert bridge type road to provide additional required spillway capacity. As to the height, the width, the invert elevation of the box culvert, all should be determined by detail flood routing.


WATERSHED AREA
WHEELER DAM
ARLINGTON MILL RESERVOIR
SCALE 1: 62500
Hoyt Hill
Chestnut Hill
Adams Pond
Phillips Pond
Butman Hill
Eastman Hill
Showell Pond
Angle Pond
West Hampstead
Hubbard Hill
Osgood Hill
Wash Pond
Howe Hill
Hubbard
Ballard Pond
Bond Hill
Colettes Grove
Island Pond
Governors Island
Hampstead
Spillway Elev 205
Escumbuit Island
Brandy Rock
Haseltine Millpond
Hog Hill Pond
Cowbell Corners
Hog Hill
North Salem
Mitchell Pond
Searles Pond
Arlington Mill Reservoir
Spillway Elev 160
Providence Hill
Shadow Lake
Jennys Hill
Our Lady of Mercy Novitiate
St Matthews Ch
Searles Sch
Canobie Lake
Salem
Ayers Village

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY | MO | YR
NH	28	NED	NH	015	02				WHEELER DAM	4249.0	7112.0	15AUG78

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	ARLINGTON MILL RESERVOIR

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	04	SPICKET RIVER	SALEM	2	20100

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	(27) IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)	(28) DIST	(29) OWN	(30) FED R	(31) PRV/FED	(32) SCS A	(33) VER/DATE
CTVAPG	1922	S	54	46	5680	3360	NED	N	N	N	N	03AUG78

(34) REMARKS

(35) D/S HAS	(36) SPILLWAY CREST LENGTH	(37) SPILLWAY TYPE	(38) SPILLWAY WIDTH (FT.)	(39) MAXIMUM DISCHARGE (FT.)	(40) VOLUME OF DAM (CY)	(41) POWER CAPACITY INSTALLED (MW)	(42) POWER CAPACITY PROPOSED (MW)	(43) NAVIGATION LOCKS NO.	(44) LENGTH (FT.)	(45) WIDTH (FT.)	(46) LENGTH (FT.)	(47) WIDTH (FT.)	(48) LENGTH (FT.)	(49) WIDTH (FT.)	(50) LENGTH (FT.)	(51) WIDTH (FT.)
1	730	C	100	6300	11000											

(52) OWNER	(53) ENGINEERING BY	(54) CONSTRUCTION BY
SPICKET RIVER CORP	HK BARROWS-CONSULT ENGR	HP CUMMINGS CONSTR CO

(55) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BD	NH WATER RES BD	NH WATER RES BD	NH WATER RES BD

(56) INSPECTION BY	(57) INSPECTION DATE DAY | MO | YR	(58) AUTHORITY FOR INSPECTION
WHITMAN + HOWARD, INC	07JUN78	PL 92-367

(59) REMARKS